ENVIRONMENTAL RISK ASSESSMENT FOR DIAZINON

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INTEGRATED ENVIRONMENTAL RISK CHARACTERIZATION

Introduction

The primary environmental concerns associated with the use of diazinon are bird kills, contamination of surface water via runoff, and impacts on aquatic species. These are significant concerns because over 6 million pounds of diazinon are used every year across the United States, with 75% being used for non-agricultural purposes (e.g., applied outdoors by homeowners and professional lawn care companies). Outdoor uses of diazinon result in exposure and risk to birds and have caused bird kills. Continued reports of bird kill incidents associated with outdoor uses of diazinon and a recent trend of increasing numbers of these incidents confirms that the outdoor uses of diazinon are resulting in widespread mortality of birds.

The impacts of diazinon use on surface water quality are a growing concern because a significant portion of diazinon is used on lawns in urban and suburban areas where runoff is generally high. Diazinon used in these areas is very prone to runoff into creeks, streams, ponds, and other bodies of water. Available water monitoring data clearly demonstrate that the use of diazinon is resulting in widespread contamination of surface water, and that impacts are particularly significant in urban settings. This contamination is resulting in exposure and risk to sensitive aquatic organisms. Potential acute and chronic effects to aquatic invertebrates as well as chronic and sub-lethal effects to fish have been identified.

Diazinon has been detected in drinking water reservoirs, large and smaller rivers, and in major aquifers. Preliminary laboratory evidence suggests chlorination of drinking water removes diazinon from treated water, transforming it to diazoxon. Diazoxon has also been found at levels about 2.5% of the parent in streams and rivers in California. Oxon degradation products of organophosphate pesticides have been shown to be substantially more toxic than parent compounds. Although diazoxon persistence has not been conclusively established, it may persist long enough to pass through the distribution system to the tap in some systems depending on the sequence of treatment. This aspect of diazinon's environmental fate warrants immediate investigation.

Diazinon is frequently found in effluent from wastewater treatment facilities (POTW's), 14 of which have been cited out of compliance with the Clean Water Act (NPDES) as a result. Also, diazinon (along with atrazine and chlorpyrifos) has resulted in the initiation of TMDL's. In California, 53 water bodies have been listed as impaired as a result of diazinon, and TMDL's have been initiated in virtually every major urban area of the state as a result. Finally, diazinon is also one of the most frequently detected pesticides in air, rain, and fog, suggesting environmental transport into regions beyond normal areas of use.

Diazinon Regulatory History

Diazinon has a long history of regulatory review and EPA has canceled certain uses and taken other risk management actions to curtail the use of diazinon because of its role in bird kills. The risk to avian species has been well documented by both field studies and an enormous number of avian mortality incidents under actual use over the years. Thus, EPA has very high certainty of this risk.

In January 1986, the EPA began the Special Review (the administrative process that can lead to cancellation) for golf course and sod farm uses of diazinon. The Special Review was initiated because of numerous bird kills associated with diazinon's use on golf courses and other turf sites. Laboratory toxicity studies and exposure data corroborated diazinon's high acute lethality.

During Administrative Law hearings in 1987, the EPA systematically described the high risk of using diazinon on golf courses and sod farms. Witnesses described laboratory toxicity data, field residue data, waterfowl feeding behavior, exposure and risk assessment modeling, bird kill incidents, and terrestrial field studies, among others. On March 29, 1988, diazinon use on golf courses and sod farms was canceled because of its high acute risk to birds. This decision was subsequently upheld in a Remand Decision of July 12, 1990, where it was determined that these uses "cause an unreasonable risk to birds commonly and with considerable frequency."

The December 1988 Registration Standard stated that the risks to birds associated with ". . . diazinon use on sod farms and golf courses appear to be substantially similar to avian risks when diazinon is used on other grassy sites . . . and that the record of bird kills . . . supports the concern that hazardous exposure regularly and routinely occurs." The risk to birds on both remaining turf and other outdoor sites was further detailed in a 1991 review that included a compilation of more than 150 avian mortality incidents. In that same year, the EPA's Assistant Administrator was briefed on these remaining diazinon uses and the potential of placing them in Special Review.

Instead of Special Review, the Assistant Administrator requested a study on clusters of pesticides used on turf (the largest diazinon use at the time). Diazinon was included as part of the pilot turf cluster study that was completed on March 1, 1993. Of the thirteen insecticides included in the study (with only one very limited exception), "the one posing the greatest risk to birds across all five pest groups that include broadcast application for all chemicals, was consistently diazinon."

All diazinon products labeled for agricultural and Pest Control Operator use are currently Restricted Use because of avian and aquatic toxicity. Therefore, these products can be used only by certified applicators or people under their direct supervision. Despite its Restricted Use labeling for agricultural uses, and the removal of golf course and sod farm uses, diazinon is still a major pesticide linked to bird kills. It is important to note that most of the diazinon used in the US is for non-agricultural purposes, including homeowner uses that are not labeled as Restricted Use .

Usage Characterization

Seventy-five percent of the diazinon used in the US each year is for nonagricultural purposes with 39% of it used by homeowners.

Up to 70% of the diazinon used every year is applied either by homeowners or by professional applicators for structural and lawn pest control around residences and public buildings. Diazinon applied in urban and suburban environments is often applied to impervious surfaces such as driveways, sidewalks, patios, and home foundations. Although some photodegradation will occur, since there is little microbial activity on these surfaces most is available for wash-off and evaporation. Much of the water monitoring data on diazinon and the incidents in this assessment resulted from the urban uses of diazinon.

Diazinon is widely used across the country with Florida having the highest amount (approximately 200,000 pounds) applied by professional lawn care applicators. The six states in the eastern north-central region have the next highest use by professional lawn care applicators (between 80,000 and 90,000 pounds). The regions listed as Southeast, Midwest, and Northeast each have between 400,000 and 600,000 pounds applied annually by homeowners for outdoor uses. California has the highest total agricultural usage, with almonds having the highest amount used on any single crop.

Environmental Fate Assessment

Diazinon is moderately persistent and mobile in the environment. It degrades primarily by microbial metabolism with half lives of 37 and 39 days in two laboratory aerobic soil metabolism studies. However, abiotic processes also contribute as hydrolysis half lives are 23, 138 and 77 days at pH’s 5, 7 and 9 respectively. Photolysis does occur with half lives of 14.7 days on soil and 26 days in aqueous solution, however, photolysis is not likely to be a major route of dissipation in most cases. Fruendlich partition coefficients estimated from batch equilibrium studies ranged from 3.7 to 23.4. Diazinon does volatilize to some degree, as evidenced by detection in air, rain, and fog reported by USGS. Field dissipation studies had half-lives ranging from 5 to 20 days, which essentially confirms laboratory data. Studies were done with three different formulations (granular, wettable powder and emulsifiable concentrate) and there were no apparent differences in field dissipation among the three formulation types.

The environmental fate characteristics of diazinon are consistent with those of compounds expected to occur in water resources. There is a considerable amount of evidence showing that diazinon does in fact occur in both ground and surface water as a result of nonagricultural and agricultural use. This evidence is discussed in the water resources section below. Diazinon bio-accumulated to somewhat over 500x in bluegill tissue. Depuration was rapid with 96% removal after 7 days.

Oxypyrimidine is the primary degradate of diazinon and is seen in both the laboratory studies and field studies. Diazoxon, an intermediate degradate which degrades further to oxypyrimidine, was detected in field dissipation studies, but was not reported to be a major degradate in laboratory studies. The reason for these differences has not been resolved. In particular, the persistence of diazoxon is unclear; because of its toxicity, this factor could have a significant impact on risk assessment. Diazoxon was also reported in air, rain and fog and surface waters. While quantitative estimates of oxypyrimidine are not available, it appears to be more persistent than diazinon. In a soil column leaching study, oxypyrimidine was the most mobile residue and occurred as 39 to 53% of the applied in the leachate.

Water Resources Assessment

There are several important conclusions that can be drawn from the available data on diazinon in water resources. One of the most serious is that diazinon has had -- and is continuing to have -- a major impact on surface water resources, including urban and agricultural creeks, streams, and rivers. To date, diazinon has been detected in the rivers, creeks, and/or streams of 30 states and the District of Columbia (with 24 of these states and DC in surface water; an additional 6 states reported diazinon in wastewater). Diazinon has also been detected in the largest rivers in the US including the Mississippi, the Rio Grande, and others. Diazinon is one of the most commonly detected insecticides in air, rain, and fog. Because of diazinon, a number of wastewater treatment facilities with NPDES permits are out of compliance with the Clean Water Act. Also because of diazinon use in urban areas, waterbodies have been listed as impaired under section 303(d) of the Clean Water Act, and Total Maximum Daily Loads (TMDLs) have been initiated for diazinon. In addition, diazinon has affected the quality of ground-water resources, including major aquifers used for drinking water. Despite poor use data, especially in non-agricultural areas, many of the detections appear to be linked to specific diazinon uses. Details on these conclusions are as follows:

Diazoxon has been found in streams and rivers in California on concentrations that 2.5% of the parent concentration on average. Evidence indicates that diazoxon is 100 to 10,000 times more toxic than the parent. While data on diazoxon in water resources are sparse, the little data available suggest that it may be the dominant toxic component of diazinon in surface waters. No data in ground or surface water is available for diazinon's primary degradate, oxypyrimidine. The paucity of diazoxon and oxypyrimidine data is a major uncertainty in the water resources assessment.

Non-agricultural uses of diazinon, including homeowner uses, have significantly affected both surface- and ground-water quality. Using a subset of samples that the USGS chose to characterize specific land uses, diazinon was detected in approximately three out of every four surface water samples collected by NAWQA in urban areas. Diazinon reached a maximum concentration of 1.9 : g/L in these urban streams. **Diazinon was detected more often in urban surface water samples (75%) than in agricultural surface water samples (17%).** The USGS NAWQA program has been able to draw several conclusions from its surface water monitoring data. According to the

USGS, insecticides were much more frequently detected in urban streams than in agricultural streams, and diazinon was the most commonly detected insecticide in urban area streams. More than 10 percent of the urban stream samples contained a mixture of at least four herbicides plus diazinon and chlorpyrifos.

Other studies confirm the impact of diazinon in urban areas. In the Castro Valley Creek watershed of California, diazinon was detected in all of the surface water samples collected during two years of monitoring. Monitoring also indicated that areas with the most undeveloped land had the smallest diazinon concentrations. Diazinon was again detected in almost all the samples from three residential studies conducted in the Castro Valley Creek watershed and Oakland, California. Diazinon was applied at 2/3 the normal application rate for ant control. Almost all of the water samples collected from the gutters, patios, roof drains, and driveways at these homes contained diazinon residues. Concentrations in the rainfall around the homes ranged up to 1.3 : g/L. In runoff samples collected adjacent to treated areas, diazinon concentrations were reported up to 1,200 : g/L, when applied at this reduced rate.

Another study in Colorado also illustrates that diazinon is detected more frequently in urban basins than those with predominantly agricultural uses as diazinon was detected in 72% of urban surface water samples versus 24% of samples in agricultural basins. The highest concentrations were measured from May through September.

In King County, Washington, a recent study showed that diazinon was detected in nine out of 10 urban streams. In all but one of the streams, the concentrations of diazinon (0.002 to 0.425 : g/L) exceeded Washington's standards for long-term exposure of aquatic life. All of the detections here are believed to be linked to homeowner lawn-care practices.

Using a subset of samples that the USGS chose to characterize specific land uses, ground-water monitoring data from the NAWQA program also show that diazinon was found more often in urban than agricultural settings. Diazinon was detected in only about 0.5% of the ground-water samples from agricultural areas, while it was detected in 1.66% of the urban samples. Concentrations were generally low with a maximum concentration of 0.077 : g/L in agricultural areas and 0.01 : g/L in urban areas.

Monitoring data indicate widespread occurrence of diazinon in surface water nationally. Diazinon has been detected in the surface water of 24 states and the District of Columbia. Using a subset of samples that the USGS chose to characterize specific land uses, NAWQA data from 1992 through 1996 shows that diazinon is the most commonly found insecticide in surface water. Diazinon was detected in 36% of the surface water samples from all NAWQA sites at concentrations ranging up to 3.80 : g/L. In urban areas, NAWQA scientists report that diazinon was detected in 3 out of every 4 samples. NAWQA data also indicate that diazinon was found in 45% of the samples collected from large streams and rivers indicating that diazinon was detected in almost 1 out of every 2 samples. Concentrations ranged up to 0.40 : g/L.

Diazinon residues have been found in large rivers and major aquifers. Diazinon has been detected in the Nation's largest river basins. From 1995 to 1998, diazinon was found in water samples collected by the USGS from the Rio Grande, Mississippi, Columbia, and Colorado rivers. Almost one-third of the samples from the Rio Grande and Mississippi rivers contained diazinon with concentrations ranging up to 0.207 : g/L. Finding diazinon in these large rivers is extremely important. Because the volume of water flowing in these rivers is very large, the pesticide concentrations reported translate into a high total mass of diazinon transported in these rivers.

Diazinon has also been detected in the major aquifers of the US; i.e., aquifers that are major current or future sources of ground water supply. NAWQA reported that diazinon was detected in 1.8% of the major aquifers it sampled, with a maximum concentration of 0.085 : g/L. Among the set of pesticides that NAWQA looked at, diazinon is one of the two insecticides found in these major aquifers (the other is carbaryl).

Diazinon has also been detected in drinking water wells located in agricultural areas of Missouri (1987-88), Mississippi (1983-84), and Virginia (1989-90) . Diazinon residues were found in deep wells in both Missouri (average of 81 feet) and Virginia (average of 200 feet), indicating that residues can be transported to relatively deep ground water. The highest concentration seen in these wells was 1.00 : g/L.

Many wastewater treatment facilities in 14 states are out of compliance with the Clean Water Act as a result of diazinon residues in effluent. Toxicity tests conducted at these facilities failed because of the presence of diazinon. According to the EPA's Permit Compliance System database, diazinon was detected in 52% of the influent samples and 40% of the effluent samples from these facilities between 1994 and 1998, with maximum concentrations of 11.0 : g/L and 10.0 : g/L for the influent and effluent samples, respectively.

A nationwide survey conducted by the National Effluent Toxicity Assessment Center confirms that diazinon is often found in wastewater treatment plant effluent (sometimes referred to as publicly owned treatment works or POTW's). This survey showed that 65% of the samples contained diazinon residues.

Individual state information from wastewater treatment facilities (POTW's) corroborates the above findings. In Texas, diazinon has caused wastewater treatment facilities to fail toxicity tests in eight large municipal systems. Diazinon residues were traced back to homeowner and commercial applicator uses. In Oklahoma, four large wastewater treatment plants have consistently failed toxicity tests from 1996 to 1998. The Oklahoma Department of Environmental Quality (DEP) believes that spring and summer lawn-care applications are the cause of the diazinon residues in the plants.

Diazinon was detected in all (100%) of the samples from three treatment plants in Contra Costa, Alameda, and Santa Clara counties, California at concentrations ranging from 0.066 to 0.940 : g/L. Diazinon was detected in 83% of the samples from the residential areas at concentrations up to 4.30 : g/l. Diazinon was also detected in 53% of the samples from nine of the 12 pet groomers, kennels, and pest control businesses at concentrations up to 20.0 : g/L.

Diazinon use by professional lawn care applicators (approximately 200,000 pounds) is higher in Florida than anywhere else in the US. Concern for diazinon in effluent from these facilities occurred as early as 1988. However, within the past five years, the State has recognized an increasing occurrence of diazinon-related toxicity in analyses of effluent. To date, diazinon has been detected in approximately 21 facilities at concentrations ranging from 0.1 to 1.57 ug/L.

TMDLs have been developed because of waterway impairments resulting from urban uses of diazinon. In California alone, 53 water bodies are impaired due to diazinon in urban runoff. Eight TMDLs have been initiated in CA, including at least one in virtually every major uban area of the state.

Diazinon is the most common organophosphate compound reported in air, rain, and fog (followed by methyl parathion, parathion, malathion, chlorpyrifos, and methidathion). Recent studies done by the USGS in the Mississippi River valley show that five insecticides, including diazinon, were frequently detected in rainfall. In two of the three urban sites, significantly more diazinon was detected in the rainfall than at the agricultural sites.

In 1971, diazinon was detected in approximately 80% of the sites sampled for air quality nationally. Over 60% of these sites also contained diazoxon. By 1988, sampling was done only in California where diazinon and diazoxon were detected in approximately 90% and 85% of the sites sampled. Concentrations of diazinon in air ranged from 0.0011 to 306.5 ng/cubic meter; for diazoxon, they ranged from 0.0014 to 10.8 ng/cubic meter. A recent USGS for pesticides in air over the Mississippi River was conducted from New Orleans, Louisiana to St. Paul, Minnesota, during the first 10 days of June 1994. Diazinon was detected in all of the samples at concentrations ranging from 0.04 to 0.36 ng/m^3. The highest concentrations of diazinon were observed near major metropolitan areas where agricultural use was minimal. Recent USGS monitoring also indicates that diazinon is being found in Sacramento urban air samples as well as samples taken in agricultural areas upwind and downwind of the urban site.

Of the 48 pesticides that have been detected in fog, only diazinon was near or exceeded the human health limits for water in 5 of 24 fog events. Concentrations of diazinon in fog ranged from 140 to 76,300 ng/L; for diazoxon they ranged from 1.9 to 28,000 ng/L.

Limited data indicate that diazinon has been found in drinking water reservoirs. Since the EPA has not established an MCL for diazinon, water supply utilities nationwide do not routinely analyze drinking water for diazinon. Preliminary results in the USGS Pilot Reservoir monitoring study show that diazinon was found in 10 of 12 drinking water reservoirs sampled (detection frequencies of 7 - 96 %), at concentrations up to 0.110 µg/L. It was found in 83 of 245 samples collected from drinking water intakes located on these reservoirs, but not found in any of 171 finished water samples. The samples were not analyzed for either diazoxon or oxypyrimidine degradates.

The properties of the degradates suggest that they can significantly impact water resources. Recent monitoring indicates that overall occurrence and concentrations of pesticides in ground water is significantly underestimated when degradates are not evaluated in addition to parent compounds.

Drinking Water Treatment affects diazinon concentrations and likely to affect diazoxon concentrations. Diazinon appears to be impacted by chlorination at drinking water treatment facilities and is likely transformed to diazoxon. The Office of Pesticide Programs has completed a review of the effects of drinking water treatment on pesticides in water (Hetrick *et al.,* 2000). This review indicates that standard drinking water treatment, consisting of flocculation/sedimentation and filtration does not substantially affect concentrations of pesticides in drinking water. However, disinfection with chlorine, the most common method, converts diazinon to diazoxon. Further, diazoxon is stable in the presence of chlorine for at least 48 hours. Disinfection is performed at greater than 92% of surface water based facilities at any size range. This is of substantial concern as the oxon degradates of other organophosphate pesticides have been demonstrated to be significantly toxic to humans, and there is evidence from ecotoxicity studies (invertebrates and fish) that diazoxon is as much as 10,000 times as toxic as parent diazinon (Fujii and Aska, 1982)

Dormant spray use of diazinon on orchard crops has resulted in surface water contamination in California. Despite heavy rainfall and lower than normal application rates, diazinon has consistently been detected in several creeks and rivers in the Sacramento River watershed and the San Joaquin River watershed where diazinon is used as a dormant spray. Diazinon has been detected in 5% to 100% of the samples during the winters after it was applied from 1991 through 1998; no detections were seen prior to applications. Concentrations were very high and ranged up to 36.8 : g/L. A USGS study also concluded that diazinon was found in urban storm runoff because of applications of dormant agricultural sprays in Modesto, California.

Environmental fate data predict that water contamination will occur from diazinon use. The environmental fate characteristics of diazinon suggest that it will occur in both ground and surface water to varying degrees. Diazinon has been found only infrequently in ground water but this may be due to poor targeting of ground water monitoring to use areas. Laboratory data indicate that oxypyrimidine (G-27550), a major degradate of diazinon, is likely to leach in vulnerable environments and would probably be found in ground water at much higher levels than parent diazinon. No monitoring information is available, however, for this major diazinon degradate. As discussed above, laboratory data indicate that diazinon will not persist in acidic waters. It should be more persistent in neutral and alkaline waters with low biological activity.

Lack of good usage data, especially for non-agricultural uses, makes it difficult to know the real impact of diazinon use on water resources. Diazinon use information is incomplete (especially the non-agricultural uses) and at too coarse a scale to identify all potentially exposed populations with any certainty. If this information were available, vulnerable drinking water sources could be identified. Surface- and ground-water occurrence could be significantly higher than in data currently available if monitoring were targeted to areas where diazinon use is known to occur. However, despite this lack of data, many of the diazinon detections can be correlated with certain use practices. The limited data also indicate that, especially for nonagricultural uses, diazinon exposure is likely to be higher in these areas than is indicated by the monitoring data.

The concentrations of diazinon found in surface water are directly related to the frequency and timing of monitoring in relation to pesticide application and storm runoff events. This is demonstrated by numerous studies that have been conducted in the Central Valley of California, particularly those that characterize the impact of diazinon used as a dormant spray. Diazinon was not detected pre-application, but detections were correlated with rainfall events. The frequency and concentration of diazinon in samples collected may have been reduced as a result of the sampling design and by flood events. Studies that demonstrate this include: Sacramento River Watershed (1996-7) and (1997-8); San Joaquin watershed 1997 and 1998. Future monitoring study designs must take this into account in order to accurately assess acute, short-term exposure.

Drinking Water Assessment

Using monitoring and modeling data, acute and chronic concentrations of diazinon in drinking water were estimated for both surface water and ground water. Since more monitoring information is available for surface water, it was possible to estimate concentrations in both agricultural and non-agricultural use areas. For both surface water and ground water, a range of values is presented with the lower end of the range derived from monitoring and the upper derived from modeling. Because of limited watershed-scale diazinon use data -- especially for nonagricultural uses -- it is difficult to determine whether currently available monitoring data represent the impact on water quality in higher use areas. Thus, it is possible that diazinon concentrations in source drinking water may be higher than indicated by available monitoring data.

Estimated diazinon exposure (:g/L) in drinking water.		
Type	Acute (monitor - model)	Chronic (monitor - model)
Surface Water		
Agricultural Use	2.3 - 70.1	0.19 - 9.4
Non-Agricultural Use	3.0 - 70.1	0.46 - 9.4
Ground Water	<0.02 - 0.8	<0.02 - 0.8

This assessment does not consider diazinon degradates. In particular, fate data for diazoxon was insufficient to support exposure analysis. The lack of diazoxon this assessment increases the uncertainty in this assessment substantially.

Diazinon Risk to Birds

Diazinon's extremely high acute risk to birds has been the focus of much of the scientific review as well as the regulatory history of this chemical. Despite regulatory attempts since 1987 to reduce bird kills (including Restricted Use labeling, the removal of golf course and sod farm uses, and lowered application rates on turf sites), diazinon continues to pose a high risk to birds, and continues to be the cause of large numbers of bird kills on outdoor use sites still registered, including lawns and turf sites.

This assessment documents in detail the extent to which diazinon exceeds established Levels-of-Concern (LOC). Diazinon acute risk quotients (RQ) for birds exceeded the high acute risk LOC (0.5), restricted use LOC (0.2), and endangered species LOC (0.1) for all uses evaluated. This was true for single as well as multiple applications, nongranular as well as granular formulations, banded/in-furrow as well as broadcast application methods, and for seed treatments. RQ values for single nongranular applications ranged as high as 75 (corn and vegetable crops); for multiple applications they ranged as high as 27 (cranberries, almonds, walnuts, and pecans). RQ values for granular broadcast applications ranged as high as 3,616 (corn); for banded/unincorporated they ranged as high as 4,725 (sorghum/sobeans). Even a single 14G granule has been shown to be capable of killing small birds. RQ values for seed treatments ranged as high as 1.57 (peas and beans). Even a single treated seed can contain 2.5 times the residue of a 14G granule, and thus contain more than enough toxicant to kill a small bird.

Diazinon chronic risk quotients for birds exceeded the chronic LOC (1.0) for all uses where this quotient is calculated. Values for single, nongranular applications ranged as high as 289 (corn and vegetable crops); for multiple applications they ranged as high as 103 (cranberries, almonds, walnuts, and pecans).

The current review has also clearly documented that bird deaths from diazinon use continue to occur with high frequency. This is particularly true on remaining turf sites, but also on agricultural sites where there are fewer observers. Diazinon has caused more documented avian mortality incidents than any pesticide except carbofuran. Diazinon use has also resulted in the highest number of reported and recorded incidents during the past five years. The majority of incidents on known sites have occurred on lawns and other turf, but incidents have also been reported on a variety of other residential sites and agricultural sites. In spite of the Agency's efforts to reduce risk to birds, reports of diazinon related bird kills have been steadily increasing.

This continued mortality, despite some lowered application rates and added label warnings by the registrants, makes it clear that such mitigation efforts are not substantially reducing bird mortality. Even at a target 2 pounds a.i. per acre rate on turf (well below the maximum rates for turf on most labels), a field study documented the death of some 85 wigeons (a type of duck) after just 30 to 40 minutes of feeding. Mortality was also significantly elevated, relative to controls, in at least one more recent turf study involving granular diazinon. Mortality is likely to continue in the future if diazinon continues to be used on sites where birds are exposed.

A number of studies have documented sublethal and indirect effects of organphosphate pesticides on birds such as reduced chick survival as a result of reduction in available arthropod food, and a reduction in avian species diversity (Southwood and Cross, 1969; Potts, 1973, 1986 and 1990, Messick et al., 1974; Palmer et. al., 1998; Nicolaus and Lee, 1998). While diazinon was not the subject pesticide in any of these studies, it is likely that these effects would apply to it and all organophosphate pesticides to varying degrees. Similarly, reports demonstrating increased toxicity of organophosphate pesticides as a result of simultaneous and sequential applications of organphosphate pesticides and carbamate pesticides, indicate that additional research is needed to more clearly show the likelihood and magnitude of increased risk to birds from multiple applications of anticholinesterase agents (Gordon et al., 1978, and Miaoka et al., 1984).

Diazinon Risks to Mammals, Reptiles and Amphibians

Terrestrial vertebrates including birds, mammals, reptiles, and amphibians may be exposed to diazinon through dermal, inhalation, oral and dietary routes of exposure. By dietary and oral routes, diazinon is classified as moderately acutely toxic to small mammals and is, therefore, considerably less toxic to mammals than to birds. The acute RQs for mammals exceeded the LOC (0.5) for broadcast applications of diazinon only. However, diazinon is chronically toxic to mammals, and the chronic RQs for mammals exceeded the LOC (1.0) for all uses of diazinon at maximum application rates. Risk to reptiles and amphibians has not been assessed in this review. There are no wild mammal incident reports in the Ecological Incident Information System (EIIS) that clearly document diazinon as the cause of death, either directly or by scavenging the carcass of a bird or other organism killed by diazinon. There are no reptile or amphibian incidents involving diazinon, except for one misuse incident where multiple organisms, including reptiles, died.

Diazinon Risk to Aquatic Animals

Because of diazinon's widespread use in the U.S., and documented widespread presence in water bodies at concentrations of concern to aquatic life, there is a high level of certainty that aquatic organisms will be exposed to potentially toxic levels of diazinon in surface water. Additionally, since diazinon and its major degradate oxypyrimidine are mobile and persistent in the environment, and found at significant levels in both ground and surface waters, it is quite probable that they will be available in quantity and for times that will exceed acute and chronic toxicity endpoints.

Aquatic invertebrates appear to be highly sensitive to diazinon on an acute and chronic basis. Acute freshwater invertebrate risk quotients range from 53.5 for grapes to 2,145 for cucumbers. Chronic RQs range from 53.5 to 2,094 for the same crops. Exceedances such as these indicate great risk potential to aquatic invertebrates at all use sites. Measured levels in surface waters from several sources exceed lethal levels, and populations of aquatic invertebrates may be severely reduced or eliminated in these areas. Populations of aquatic invertebrates may recover over time but their lowered numbers can potentially have an effect on the health of animals that prey on them depending on alternative food sources and the overall health of the aquatic ecosystem prior to the introduction of the toxicant. Additionally, it is difficult to assess long-term sublethal effects levels of diazinon, pulses of toxicants entering water systems, and the effects of multiple toxicants found in the surface waters.

As described in the water assessment, diazinon has been found in the effluent from Privately Owned Treatment Works (POTWs) in 14 states. Although there is usually a mixture of compounds which may be responsible for the failure of these plants to meet effluent standards, diazinon has been measured in the effluent at levels shown to be lethal to aquatic invertebrates.

In urban areas, small streams are often affected by the water collected in storm sewers. These small streams can provide significant habitat for aquatic animals and this habitat can be severely degraded by runoff of urban pesticides. Lawn care products and other outdoor uses such as the treatment of paved areas (sidewalks, driveways, and patios) around dwellings contribute to diazinon in storm sewers. In California, diazinon concentrations measured in storm sewer waters and small creeks ranged up to 2.6 ug/L; in one survey where 167 samples were taken, diazinon was at levels lethal to aquatic invertebrates in 27% of the samples.

Although diazinon does not appear to be as acutely toxic to fish as it is to freshwater aquatic invertebrates, the estimated environmental concentrations from the water modeling are within the range of acute toxicity to fish for some application rates. Acute mortality to fish is thus a possibility, even though there are no reported fish kill incidents in EIIS which have been clearly caused by diazinon. Chronic RQs for freshwater fish range from 11.6 for almonds to 469 for cucumbers. Such exceedances indicate that chronic effects to fish are clearly possible. There are reports of reduced reproduction rates, malformed fry, and lowered cholinesterase levels in fish exposed to low levels of organophosphates in water. Additionally, stresses on aquatic invertebrates (which often serve as a primary food source for some fishes), pulses of toxicants with varying periods of recovery, multiple toxicants and the additive or multiplicative effects of other stressors make the risks of diazinon to fish difficult to assess. In certain terrestrial field studies on turf, pond residues sometimes exceeded invertebrate LC_{50} values and, in one case after a rainstorm, exceeded the lowest fish LC_{50}. Fish using invertebrates as a large portion of their food supply could potentially be impacted if the invertebrate species are sensitive to diazinon. In addition, if such fish were already impacted by other stressors (e.g., sedimentation), they might be unable to recover even if the other stressors are removed because of the stress caused by diazinon.

Diazinon acts as an anticholinesterase agent by phosphorylating acetylcholinesterase (AchE) (Menzer 1991). In so doing, diazinon interferes with the metabolism of acetylcholine which results in the accumulation of acetylcholine at neurorecetor transmission sites. Exposure generally results in a broad spectrum of clinical effects indicative of massive overstimulation of the cholinergic system, including muscarinic effects (parasympathetic), nicotenic effects (sympathetic and motor), and central nervous system effects (Rumack and Lovejoy 1991). Although diazinon’s primary mode of action is characterized as inhibiting acetylcholinesterase (AchE), the parent compound itself cannot inhibit AchE but requires preliminary oxidation to its oxon, *i.e.*, diazoxon (Keiger *et al.* 1995). The diazinon biotransformation products diazoxon and isopropyl diazoxon exhibit AchE inhibition activity 10^4-fold higher than the parent (Fujii and Aska 1982).

The sensitivity of species to diazinon is to a large degree dictated by the organism’s ability to biotransform the parent to its toxic diazoxon and the organism’s ability to further transform the diazoxon to nontoxic forms. Marked differences in the ability of fish to biotransform the diazoxon account for differences in the sensitivity of species. Although carp bioconcentrate diazinon at roughly twice the ratio (120X) than rainbow trout (63X) (Seguchi and Asaka 1981), rainbow trout are more sensitive to diazinon than carp owing largely to the limited capacity of trout to further degrade the toxic diazoxon (Keiger *et al.* 1995). Additionally, studies have shown that marine fish may be more sensitive to diazinon due to differential degradation activity (Fujii and Asaka 1982).

Following acute exposure to diazinon, fish have exhibited lethargy when undisturbed, abnormal forward extension of the pectoral fins, darkened areas on the posterior part of the body, and when startled, sudden rapid swimming in circles followed by severe muscular contractions. In chronic studies, external signs of poisoning included abnormal darkening of areas of the body, reduced growth of both parent and progeny, anterior projection of the pectoral fins, abnormal curvature or flexure of the body (scoliosis and lordosis), and muscular tetany during capture (Allison and Hermanutz 1977; Goodman *et al.* 1979; Eisler 1986). AchE activity varied inversely with exposure concentrations (Goodman *et al.* 1979).   Reproductive effects were noted in tests with sheepshead minnows (*Cyprinodon variegatus*) and brook trout (*Salvelinus fontinalis*) where the number of eggs spawned was significantly reduced among fish treated with diazinon at 0.47 - 6.5 : g/L (Allison and Hermanutz 1977; Goodman *et al.* 1979. Fish previously exposed to diazinon and then transferred to clean water for 23 - 31 days produced significantly fewer eggs than control fish suggesting a residual effect on fish reproduction. In the Allison and Hermanutz study, the authors comment that given exposure concentrations of 4.8 and 9.6 : g/L, mortality and inhibition of ovarian development and spawning response of brook trout would result in approximately one-quarter to one-half of the female population not contributing to reproduction and that if initial exposure of brook trout to diazinon coincided with the spawning period, the effect on reproductive potential could extend beyond their estimate. It is of note that these concentrations are well within the range of estimated environmental concentrations.

As might be expected from AchE inhibitors, symptoms indicative of neurotoxicity are common and as with many organophosphate pesticides, high exposure results in death through asphyxiation as muscles associated with respiration undergo tetany. However, data on the sublethal effects of diazinon, particularly those associated with neurotoxicity have only recently become available. In studies conducted by Moore and Warring (1996), diazinon inhibited *in vitro* olfactory function in male Atlantic salmon *(Salmo salar*) parr. Fish olfactory epithelium exposed to diazinon at environmentally relevant nominal concentrations (0.3 - 4.5 µg/L) exhibited reduced response to prostaglandin $F_{2\alpha}$, an odorant involved in synchronizing spawning physiology and behavior between males and females and in having a priming effect on plasma steroid and gonadotropin levels in salmon parr. Male salmon plasma steroid (17, 20β dihydroxy-4-pregnen3-one) and gonadotropin II levels failed to increase in diazinon-treated fish exposed to the female prostaglandin. Additionally, diazinon exposed males also exhibited declines in expressible milt. Failure of male fish to respond to female pheromones was hypothesized to potentially impact the reproductive success of wild fish by interfering with salmon's ability to detect natal stream odorants and by decreasing the receptivity of male fish to females. Additionally, exposure to atrazine (10-200 ppb) enhanced the toxicity of diazinon by increasing the biotransformation of diazinon to its toxic oxon degradate (Beldon and Lydy 2000).

Further studies of chinook salmon (*Oncorhynchus tshawytscha*) revealed diminished *in vivo* olfactory response to avoiding predation and affecting the salmon's homing ability, *i.e.*, detecting natal waters (Scholz *et al.* 2000). These data suggest that salmon exposed *in vivo* to environmentally relevant concentrations of diazinon (0.1 - 10 µg/L) were significantly less cognizant of a threat of predation and continued feeding while control fish became quiescent. The data also support previous findings of Moore and Warring (1996)

Diazinon effects on aquatic species include growth, reproduction and survival and recent literature has indicated that these effects may be enhanced by collateral exposure to other pesticides, *e.g.*, atrazine. Chronic sublethal effects may also increase the vulnerability of aquatic species to predation. Vulnerability factors for substandard prey to predation include a failure to detect predators, lapses in decision-making, poor fast-start performance, inability to shoal effectively, and increased prey conspicuousness (Mesa *et al.* 1994). Sublethal effects including lethargy, decreased olfactory ability leading to failure to detect predators, and unusual movements in the water stemming from scoliosis, lordosis and poor fin coordination are likely to increase the conspicuousness of aquatic organisms and thereby increase there vulnerability to predation.

Historically, acute sublethal effects such as the those reported on olfaction in salmonids have not factored into EFED risk characterizations. Sublethal effects are usually characterized through chronic toxicity testing and the risks associated with those effects are reflected in chronic risk quotients. Thus, while recent literature indicates that some fish species may be affected by diazinon concentrations of 0.1

: g/L (Moore and Warring 1996) and this estimate is over 4 orders of magnitude below estimates of acute toxicity (rainbow trout LC_{50} = 190 : g/L), chronic toxicity estimates for fish (brook trout NOEC < 0.55 : g/L) differ by a factor of 5.5. Chronic RQ values for diazinon ranged from 12 - 469; however, since any chronic RQ value greater than or equal to unity exceeds the chronic level of concern, the recent literature would do little increase the level of chronic risk portrayed in the chapter. As a rough estimate though, RQ values would increase by a factor of 5.5 (RQ range 66 - 2,580) if based on the revised estimate of sublethal effects. It is not possible however to say that the risk at an RQ of 2,580 is 5.5-times the risk at an RQ of 469. Rather, the utility of the most recent data in characterizing risk is open to interpretation.

While the recent literature raises concerns about the effects of diazinon on factors affecting growth, reproduction and survival of nontarget species, those effects are difficult to quantify at a deterministic level of assessment. The Scholz *et al.* (1996) study clearly indicates that *in vitro* olfactory effects documented in the lab can account for *in vivo* behavioral changes; however, these studies were conducted in controlled settings and their relationship to wild salmon populations is uncertain. Additionally, both the Schulz *et al.* (2000) and the Moore and Warring (1996) studies were conducted on immature salmon. The responsiveness of some salmon species to environmental clues is dictated by their level of maturity and many salmon species are most receptive to environmental clues (olfactory imprinting) during smoltification, *i.e.*, the physiological process whereby immature freshwater salmon (parr) prepare to enter a marine environment, and are associated with surges in plasma levels of the hormone thyroxine (Dittman and Quinn 1996). The authors note that imprinting prior to the smolt stage is not observed in some hatchery-reared salmon species because the stable rearing conditions provide insufficient environmental stimuli for full thyroid function except during the parr-smolt transformation. The Scholz *et al.* (2000) study was also confounded by the unusually low homing rate (30%) exhibited by control fish.

In spite of discrepancies and confounding effects, the recent literature does document direct biological effects on a species, *i.e.*, chinook salmon, with populations currently listed as threatened and/or endangered (U. S. Fish and Wildlife Service Species Profile 10/13/2000). Additionally, the Atlantic salmon are currently proposed for listing as endangerd (U. S. Fish and Wildlife Service Species Profile 10/13/2000). In Washington the U. S. Geological Service's surface water sampling sites reported diazinon detections in up to 22% of those sampled; in California and Oregon diazinon was detected in as many as 100% of the samples collected (NAWQA 1993 - 1996). In all three states water sampling was conducted from streams that serve as habitat for salmon. Environmental concentrations of diazinon in Washington, Oregon, and California ranged as high as 0.04 : g/L, 0.2 : g/L, and 0.8 : g/L, respectively. Thus, from an exposure perspective, diazinon concentrations used in conducting recent laboratory studies are environmentally relevant; risk quotients based on actual measured effect and exposure data (0.8 : gL^{-1}/0.1 : gL^{-1} = 8) again exceed chronic LOCs. Concern has been raised that olfactory effects on salmon may result in a decreased ability of fish to reach their natal streams and increase the rate of straying, *i.e.*, spawning in non-natal streams. Since salmon populations have evolved to spawn on very specific substrates (Dittman and Quinn 1996), straying could reduce spawning success and diminish the genetic "purity" of specific salmon stocks. (Schulz *et al.* 2000). Increased predation due to greater conspicuousness of young salmon due to sublethal effects of diazinon and potential reductions in reproduction could further adversely impact threatened/endangered species.

There is high certainty that in all urban and suburban areas where diazinon is applied outdoors, and where there is sufficient irrigation or rainfall to cause runoff, there will be negative impacts on aquatic biota from the diazinon use.

Diazinon Risk to Non-target Insects, Particularly Honeybees

Currently, EFED does not assess risk to nontarget insects. Results of acceptable studies are used for recommending appropriate label precautions.

Diazinon is highly toxic to honeybees and can be expected to cause mortality in the field. There are two diazinon bee kill incidents in EIIS, both related to spray applications in ranch areas in California. This toxicity results from direct and residual contact. At a 1.0 lb ai/A spray application rate, an emulsifiable concentrate diazinon formulation can be expected to be lethal to honey bees exposed to direct contact and for up to 2 days from foliar residue exposure (Johansen and Mayer, 1990). Diazinon is currently registered at maximum application rates of 10 lb ai/A with typical application rates of 4 lb ai/A on numerous agricultural crops that could be expected to attract bee activity. The Agency is requiring additional data be submitted for diazinon to redefine the residual toxicity at the maximum rate of application.

Most bee kills result from insecticide and/or miticide applications to blooming and/or pollinating plants, although other classes of pesticides such as certain herbicides and fungicides can also produce bee kills. The bees are killed when exposed to the toxicant while foraging for nectar, pollen, propolis (tree resin or sap) or water. Diazinon's major route of exposure to bees is anticipated to result from contact while bees are foraging in and around agricultural crops. This contact results in destruction of the colony's field force, disruption of the colony's life cycle and, as a result, economic losses to beekeepers.

A recent survey of its members by the American Beekeeping Federation, Inc. indicated ". . . that bees continue to sustain major losses from pesticides in many parts of the United States. Sixty beekeepers, operating 127,950 colonies in 22 states, reported that bee losses from pesticides are a significant issue in their operations." The survey results indicated 35,970 colonies were damaged from pesticides in 1995 and 36,192 colonies in 1996. Pesticides were ranked in order (most to least damage) according to the number of bee kill responses. Diazinon ranked 13th in a listing of 35 pesticides causing this damage (Brandi, 1997).

As a result of the Diazinon Registration Standard (revised 1989) all diazinon end-use products (excluding granular formulations) intended for outdoor use were required to revise the labeling to provide statements indicating the products had both contact and residual toxicity to bees. However, due to enforcement and interpretation problems with these statements and continued bee kill problems, the Agency is currently working with the State Labeling Issues Panel (SLIP) to revise the bee labeling again. The new labeling is expected to provide enforceable language and define the residual time period for all pesticides that are toxic to bees.

Diazinon Risk to Endangered Species

Endangered species LOCs are exceeded for multiple taxonomic groups of organisms on most application sites. The USFWS has determined that diazinon is likely to jeopardize multiple aquatic and terrestrial species (5/18/83 Biological Opinion on chemicals used on corn; 10/12/83 Biological Opinion on chemicals used on sites including sorghum, cotton, and soybeans; 12/11/84 Biological Opinion on chemicals used on rangeland; 6/14/89 and 9/14/89 revised Biological Opinions on a Reinitiation of previous use clusters; and a 1/17/86 Biological Opinion on golf courses and sod farms). The 9/14/89 Biological Opinion, for example, lists a total of 88 federally-listed endangered/threatened aquatic and terrestrial species that the USFWS considers to be in jeopardy due to diazinon use. Corn, sorghum, cotton, and soybeans covered by this Biological Opinion are among the use sites listed in the January 22, 1999 Use Closure memo that were included in this environmental risk assessment.

In 1989 the U.S. Fish and Wildlife Service (USFWS) issued a biological opinion (USFWS 1989) on diazinon in response to the U. S. Environmental Protection Agency's request for consultation. In issuing its opinion the USFWS considered the following factors: (1) potential for exposure of the listed species to the pesticide; (2) information on the chemical toxicity relative to estimated environmental concentrations; (3) potential for secondary impacts; and (4) special concerns not specifically addressed in the preceding factors or unique to the situation being evaluated. Given the evaluation criteria, a total of 132 species (5 bird, 6 amphibian, 77 fish, 32 mussel, 6 crustacean, 4 miscellaneous aquatic invertebrates, and 2 snake species) were considered potentially affected by the use of diazinon. Of those organisms potentially affected, the USFWS listed 84 aquatic species as jeopardized, of which the majority (56%) were endangered/threatened species of freshwater fish. Four terrestrial (avian) species were also classified as being in jeopardy. The remaining potentially affected organisms were listed either as having no potential for exposure or as not being in jeopardy.

For all of the species listed as jeopardized the USFWS lists reasonable and prudent alternatives (RPA) to mitigate the effects of diazinon use. For some of the species listed as not jeopardized, the USFWS lists reasonable and prudent measures (RPM) and incidental take (IT) to mitigate effects. For details on the RPA and RPM recommendations, the reader is referred to USFWS 1989 publication. Many additional species, especially aquatic species, have been federally listed as endangered/threatened since the biological opinion of 1989 was written, and determination of jeopardy to these species has not been assessed for diazinon. Additionally recent literature does document direct biological effects on a species, *i.e*., chinook salmon, with populations subsequently listed as threatened and/or endangered (U. S. Fish and Wildlife Service Species Profile 10/13/2000) or proposed for listing, *e.g*. Atlantic salmon (U. S. Fish and Wildlife Service Species Profile 10/13/2000). As noted earlier, sublethal effects could reduce reproductive success, diminish the genetic "purity" of specific fish stocks, increase vulnerability to predation and thereby adversely impact threatened/endangered species. **EFED strongly recommends that FEAD evaluate the need to conduct a consultation with the responsible agencies to address endangered species concerns**.

USE CHARACTERIZATION

Diazinon is a broad spectrum organophosphate insecticide registered for use on a variety of terrestrial food, feed, and nonfood crops, greenhouse food and nonfood crops, residential outdoor, and indoor food and nonfood uses. Novartis is the primary manufacturer of the active ingredient and is the only registrant providing information for supporting diazinon uses; Makhteshim-Agan America is a minor supplier of technical product and is relying on data generated by Novartis. There are multiple formulators with approximately 430 products with current (i.e., active) registrations. According to the current labels, diazinon of the 14-G, 50 WP, and 48 EC formulations is applied foliarly or as a soil treatment using ground or aerial equipment followed by incorporation in some uses. Diazinon is used widely throughout the United States with California, Florida and Texas listed as states with the highest usage.

According to the *Quantitative Usage Analysis* for diazinon developed by the EPA's Office of Pesticide Program's (OPP's) Biological and Economic Analysis Division (BEAD, dated 1/29/99), there were approximately 6 million pounds of active ingredient (a.i.) diazinon used in the US each year from 1987 through 1996. In terms of total pounds a.i., usage is approximately divided as 2.34 million pounds used by homeowners outdoors (39%), 1.14 million pounds used by professional lawn care companies (19%), 660,000 pounds applied by pest control operators indoors and outdoors (11%), and 1.52 million pounds for agricultural uses (25%). The balance of 341,000 pounds a.i. (6%) used annually is divided between indoor uses by homeowners and veterinary uses.

According to OPP's Special Review and Reregistration Division (SRRD, Use Closure Memorandum, dated 1/22/99), diazinon's uses are as follows:

<u>Indoor, commercial property and lawn/ornamental uses</u>: food/feed handling establishments (crack and crevice treatment only), inside/outside domestic dwellings and commercial buildings, lawns, livestock quarters (dairy barns, milk rooms, poultry houses), ornamentals (including greenhouse).

<u>Animal treatments</u> pet collars (cats and dogs), non-lactating cattle, and sheep.

Foods for human and animal feeds: almonds, apples, apricots, lima beans (succulent only and seed treatment), snap beans (succulent only and seed treatment), red table beets, blackberries, blueberries, boysenberries, brassica leafy vegetables, cantaloupes, carrots, melons (casaba, crenshaw, honeydew, musk, Persian, and watermelon) cauliflower, celery, cherries, collards, sweet corn (including seed treatment), cranberries, cucumbers, dewberries, endive, ginseng, grapes (table, raisin and wine), hops, kale, lettuce, loganberries, mushrooms, mustard greens, Chinese mustard, nectarines, onions (green and bulb), parsley, parsnips, peaches, pears, peas (succulent only and seed treatment), peppers, pineapples, plums, potatoes, prunes, radishes, Chinese radishes, raspberries, rutabagas, seed treatment (planter box) for corn, succulent peas, and succulent beans, spinach, squash, (summer and winter), strawberries, sugar beets, sweet potatoes, swiss chard, tomatoes, turnips (roots and tops), walnuts, alfalfa, bananas, citrus, field corn, clover, cotton, cowpeas, filberts, lespedeza, pecans, sorghum, soybean, sugarcane, and tobacco.

US crops where the maximum estimated percent of the crop treated with diazinon is 30% or more are: nectarines (100% treated), Brussels sprouts (100%), hops (84%), cranberries (75%), romaine lettuce (68%), apricots (68%), prunes (64%), spinach (for processing; 60%), plums (54%), other lettuce (52%), beets (53%), raspberries (45%), greens (39%), head lettuce (39%), and almonds (30% treated).

Application Rates and Methods

Diazinon can be applied by ground, chemigation or aerial equipment. There are three main types of formulations: wettable powders, granular and emulsifiable concentrates and more than 400 products. Diazinon can be applied with horticultural oils, in water, or tank mixed with other compounds. Application rates and timing are determined by the intended target pest with many applications to be "repeated as necessary." Crops which received soil applications at planting to treat for soil insects may also be sprayed later in the season for foliar insects.

To keep pests from residential structures, a mixture of 0.033 lbs ai per gallon of water can be used to thoroughly spray porches and patios, walkways, window and door sills and screens, garbage cans, tree trunks and any cracks where insects can hide. A foundation spray is allowed by treating a five-foot band of soil around the house next to the foundation and the foundation to 2-to-3 feet in height. These applications may be repeated "as necessary."

For lawn treatments, up to 0.094 lbs a.i./1000 square feet (ft^2) of lawn (4.1 lbs a.i./A) can be applied when insects first appear with treatments repeated as necessary. The label states that if waterfowl are expected to enter the treated area, the treated lawn should be watered with at least 0.25 inches of water; irrigation should be stopped before puddling occurs. Fire ants are to be treated with 0.00625 lbs a.i./mound with new fire ant mounds treated as they appear.

For ornamentals, up to 1.5 lbs a.i./100 gallons of water are to be applied when insects first appear and repeated as necessary. Thorough spraying including undersides of leaves and penetration of dense foliage is recommended. Ferns, poinsettias, hibiscus, papaya, pilea and gardenias are sensitive to diazinon, and labels indicate that they should not be treated to avoid plant injury.

For livestock structures (except dairy barns, milk-rooms and poultry houses) solutions are mixed to 0.08 lbs a.i./gallon of water. Ceilings and walls of structures are sprayed until runoff occurs. Garbage dumps and animal corrals may be “sprayed thoroughly.” These sprays may be mixed with sugar for baits. Applications may be repeated as necessary which may be daily or every other day. Animals must be removed from structures prior to treatment and not returned to structures for at least 4 hours after treatment.

For agricultural uses to treat for soil insects, diazinon is applied at planting and most applications are incorporated 4-to-8 inches depending on the pest. The highest at-plant application rate is 9.8 pounds for centipedes on corn. More typically, at-plant applications are 3-to-5 pounds of active ingredient per acre treated (lbs ai/A).

For agricultural uses to treat for foliar insects, most applications are made when “insects first appear” and may be repeated as necessary. Most of the recent labels state that a maximum of five applications can be made with at least a 7-day treatment interval. Several less recent labels do not specify a maximum number of applications. The highest foliar application rate is 10 lbs ai/A/application. More typically, at-plant applications are 0.5-to-4 lbs a.i./A/application.

For grassland insects, rangeland, ditch-bank, roadside, wasteland, noncrop areas and barrier strips are sprayed with 0.5 lbs a.i./A in water or oil “when insects first appear.”

Target Organisms and Mode of Action

Multiple insects are target organisms for diazinon including: scale insects, aphids, leaf-hoppers, leaf-rollers, moths, mealybugs, fruit maggots, crawlers, mites, fruitworms, fruit flies, fireworms, tip worms, psylla, mole crickets, caterpillars, thrips, ants, beetles, cutworms, wireworms, armyworms, weevils, millipedes, centipedes, grubs, bagworms, webworms, mushroom flies, grasshoppers, lice, ticks, fleas, chiggers, houseflies and cockroaches. Diazinon is not effective against the many insect species which are resistant to organophosphate insecticides.

Diazinon is a contact insecticide which kills by cholinesterase inhibition. It is nonsystemic in plants, so thorough coverage of surfaces is necessary for control.

CHEMICAL PROFILE

Chemical name	O,O-Diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl)phosphorothioate.

Common name	diazinon
Trade names	D.z.n., Dazzel, Diagram, Dianon, Diaterr-Fos, Diazajet, Diazatol, Diazide, Dizinon, Dyzol, G-24480, Gardentox, Kayazinon, Kayazol, Nipsan, Spectracide, PT 265.
CAS Number	333-41-5.
Molecular formula	$C_{12}H_{21}N_2O_3PS$
Molecular weight	304.3.
Kow (log)	3.3
Solubility at 20 C	40 mg/L in water; completely miscible in acetone, benzene, cyclohexane, diethyl ether, ethanol, methylene chloride, octan-1-ol, and toluene.
Vapor pressure	1.40×10^{-4} mm Hg @ 20 C
Henry's Law Constant	1.40×10^{-6} atm m^3/mol
Formulations:	Dust, emulsifiable concentrate, oil, granular, impregnated materials, wettable powder, soluble concentrate/liquid, ready-to-use, pressurized liquid, and microencapsulated.
Degradate names	**oxy-pyrimidine**, referred to as G-27550, 2-isopropy-6-methyl-4-pyrimidinol
	De-methyl oxy-pyrimidine 2-ethyl-4-hydroxy-6-methyl pyrimidine
	GS-31144 was identified as 2-(1-hydroxy-1-methyl ethyl)-4-hydroxy-6-methyl pyrimidine,
	diazoxon, is O,O-diethyl-O-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphonate.

EXPOSURE CHARACTERIZATION

ENVIRONMENTAL FATE ASSESSMENT

The properties of diazinon and its main environmental degradate, oxypyrimidine, suggest that they are mobile in the environment and may be persistent enough to significantly impact water resources. Diazinon has an aqueous solubility of 40 mg L^{-1}, a log Kow of 3.3, and a vapor pressure of 1.4×10^{-4} mm Hg @ 20 C. Diazinon has a reported Henry's law constant of 1.4×10^{-6} atm m^3/mol which would indicate that diazinon would not volatilize from soil or water. However, there are studies which report vaporization from water of up to 50% of applied (Howard, 1991). Diazinon (along with its degradate diazoxon) is one of the organophosphate pesticides that has been most frequently detected in air, rain, and fog according to reports from the United States Geological Survey's National Water Quality

Assessment program (USGS Fact sheet FS-152-95). Maximum measured concentrations range up to 2,000 ng/L in rain, 306 ng/m^3 in air and 76,300 ng/L in fog (Majewski and Capel, 1995).

In the environment, diazinon appears to degrade by hydrolysis in water and by photolysis and microbial metabolism and to dissipate by volatilization from impervious surfaces.

Diazinon degrades by hydrolysis at all pH's tested. Hydrolysis is rapid under acidic condition with a half-life of 12 days at pH 5. Under neutral and alkaline conditions, diazinon hydrolyzed more slowly with abiotic hydrolysis half-lives of 138 days at pH 7 and 77 days at pH 9. Diazoxon is the first degradate formed by oxidation and it rapidly oxidizes further to oxypyrimidine. Diazinon is stable to photolysis in water, but was shown to degrade with a half-life of less than two days on soil indicating that photodegradation may be important under certain circumstances.

The major route of dissipation for diazinon appears to be soil metabolism; first order aerobic soil half-lives were 37 days (sandy loam soil pH 5.4; R-square=0.93) and 39 days (sandy loam soil pH 7.8; R-square=0.98). Diazinon also degraded in soil under anaerobic conditions; half-lives were 17 and 34 days when samples were amended with glucose. These half-lives cannot be compared to the aerobic soil metabolism studies conducted without amendment, but it is clear that diazinon will degrade under anaerobic conditions. A laboratory anaerobic aquatic metabolism study showed rapid degradation of diazinon in a cranberry bog sediment:water system conducted at pH 5 and amended with glucose.

Batch equilibrium studies conducted with European soils gave adsorption Freundlich coefficients 3.7, 4.5, 5.6, and 11.7 mL/g showing that diazinon is not expected to adsorb to soils to a significant degree. Diazinon binding in soil is correlated with organic carbon content; the K_{oc} of 758 L (kg-organic C)$^{-1}$ Italian researchers reported that in 25 soils tested, Rf values indicate that diazinon was slightly mobile in 80% of soils tested and immobile in 20%. In saturated columns, diazinon was shown to leach in light textured soils with low organic matter (Arienzo et al., 1994).

In column leaching studies submitted to the Agency, diazinon residues which had been aged 30 days were shown to be mobile in columns of Lowell sand, Hanford sandy loam, Huntington loam and Armor silty clay soils. In the leachate, 2.5% of the applied radioactivity was recovered as diazinon and up to 53% of the applied was recovered as oxypyrimidine. The major diazinon degradate, oxypyrimidine, appears to be more persistent and mobile in soil than the parent. Oxypyrimidine is also more stable under anaerobic than aerobic conditions.

Diazoxon is the primary degradate formed by the hydrolysis of diazinon; diazoxon retains the o-p moiety and is a stronger cholinesterase inhibitor than parent diazinon. Diazoxon hydrolyzes rapidly to oxypyrimidine under most circumstances. It was not recovered from any of the laboratory studies, but was recovered from 4 of the 12 field studies.

In experiments conducted to test models for wastewater treatment, diazinon in activated sludge and wastewater was not significantly sorbed, was not volatilized by aeration and was not readily biodegradable in wastewater treatment trials (Monteith, 1994).

In several supplemental terrestrial field dissipation studies submitted to the agency, diazinon dissipated with apparent field half-lives ranging from 5-to-20 days in the top 0- to 6-inch soil layer. These dissipation half-lives are consistent with a compound which is registered for multiple applications for adequate pest control. These studies measure dissipation resulting from degradation, dilution and movement from site. In one Florida study and one New York study, diazinon was detected to a depth of 48 inches; however, in most studies, diazinon was recovered at a maximum of 18 inches.

Oxypyrimidine was measured in all field studies; half-lives were not calculated in the field studies, but oxypyrimidine did not significantly degrade in the anaerobic soil metabolism studies or in the column leaching study. Oxypyrimidine was shown to be very mobile in laboratory studies and was recovered at the 48-inch depth at several sites and at the 72-inch depth at an Illinois field dissipation study site.

ENVIRONMENTAL FATE AND TRANSPORT DATA

(1) Degradation

(a) Hydrolysis

Diazinon hydrolyzed with a half-life of 12 days in a sterile mildly acidic (pH 5) solution at 23 to 25°C. The rate of hydrolysis decreased in neutral (pH 7) and mildly basic (pH 9) solutions with half-lives of 138 and 77 days, respectively. Oxypyrimidine was the major degradate identified in the three solutions (Matt, MRID 40931101).

In an investigation of hydrolysis of diazinon and diazoxon, it was reported that in pure water at 20° C, the hydrolysis half-life of diazinon was 0.5 days at pH 3.1, 31 days at pH 5.0, 185 days at pH 7.4, 136 days at pH 9.0 and 6 days at pH 10.4. In general, diazoxon was found to oxidize faster than diazinon. At acidic pH's the rate is 30 times (x) faster than diazinon, 7x faster at pH 7.4 and 14x faster at pH 10.4 (Gomaa, Suffet and Faust; Accession # 251777).

(b) Photodegradation

<u>Photodegradation in Water</u>: Degradation in the irradiated solutions was primarily due to hydrolysis rather than photolysis. This conclusion was drawn by comparing the half-lives of the irradiated versus the dark control solutions (10.75 versus 13.54 days). The half-life from photolysis alone would be greater than 26 days. Oxypyrimidine was the major degradate (Spare, 40863401).

Photodegradation on Soil: [14]C-Diazinon degraded on sandy loam soil exposed to natural sunlight with a half-life of 20 hours when corrected for the dark control degradation. The half-life for diazinon in the non-exposed sample was 14.7 days. The degradate, oxypyrimidine, was detected at levels of 23.7% of the applied material after 1.4 days of sunlight exposure. Another degradate, GS-31144 was present at 3.6%. The mechanism of degradation is unclear since there are no obvious chromophores on the molecule and diazinon did not degrade by photolysis in water or appear to absorb light in buffered solutions (Martinson, MRID 00153229).

(c) **Aerobic soil metabolism.** Diazinon degraded in a sandy loam soil (54.8% sand, 29.4% silt, 15.8% clay, 2% om, pH 5.4) with a half life of 37 days (R^2=0.93) under aerobic conditions. The soil series name was not provided. The major degradate was oxypyrimidine reaching 67% of the applied after 95 days and decreased to 37% at 195 days and further to 13% by 371 days posttreatment. Oxypyrimidine is more stable than diazinon under aerobic soil conditions. A second degradate was identified as GS-31144 at a maximum concentration of 12.8% after 6 months. There was no radioactivity recovered in volatile traps in this study indicating no mineralization to CO_2 (Das, Fiche ID 400287).

In a second supplemental study, [14]C-labeled diazinon degraded in a sandy loam soil from California (76% sand, 17% silt, 7% clay, pH 7.8, CEC 9.3 meq/100 g, 1.3% om); with a first-order calculated half-life of 39 days (R^2= 0.98). The soil series name was not specified. Degradates were oxypyrimidine, GS-31144, and at least two minor compounds comprising a total maximum of 5.1% of the applied at 272 days posttreatment; these minor compounds did not separate under the thin layer chromatography (TLC) systems used for identification in this study. Oxypyrimidine comprised a maximum of 42% of the applied radioactivity at 90 days posttreatment and had decreased to 2% of the radioactivity by the next sampling interval at 180 days posttreatment. At the final sampling interval of 366 days posttreatment, 44% of the radioactivity was recovered as volatiles with 13% in ethylene glycol traps, 1% in sulfuric acid and approximately 30% of the radioactivity was recovered as CO_2. This study was flawed by a loss of up to 30% of applied radioactivity for the last sampling intervals which the registrant assumed to be CO_2. There were no sampling intervals between 30 and 90 days and there was no comparison between the two metabolism studies to explain the lack of volatilization in the first study (Spare, MRID 44746001).

(d) **Anaerobic soil metabolism.** Diazinon degraded under anaerobic conditions in a study with the same sandy loam soil (54.8% sand, 29.4% silt, 15.8% clay, 2% om, pH 5.4); this is the same soil used in one of the aerobic soil metabolism studies (Das, Fiche ID 400287) and the soil series was not reported. The reported half-life was 34 days; however, this study was conducted with 1% added glucose, so the rate of degradation is not comparable to the aerobic half-life or to anaerobic half-lives from other anaerobic studies. Oxypyrimidine was the major degradate comprising a maximum of 41% of the applied radioactivity at the final sampling interval of 95 days post-treatment (Das, Fiche ID 400287).

(2) Mobility

Diazinon was shown to be moderately mobile in five soils from Switzerland with reported Freundlich adsorption coefficients ranging from 3.7 to 23.4 mL/g; this information is considered to be supplemental because there were inadequacies in the methodology report and no information was provided for US soils. Information regarding the Swiss soils is summarized in the table below:

Freundlich Kd values are proportional to the organic carbon content with an R-square of 0.96 and K_{oc} of 758 L (kg-organic C)$^{-1}$ (Guth, MRID 00118032).

In a soil column leaching study, aged (30 days) diazinon residues were mobile in columns of Lowell sand, Hanford sandy loam, Huntington loam, and Armor silty clay soils that were leached with 20 inches of a 0.01 M calcium ion solution. Parent diazinon was not mobile as evidenced by rapidly decreasing concentrations in soil with increasing depth and low amounts in the leachate (<2.5 % of the applied radioactivity). Oxypyrimidine (G-27550), the major degradate of diazinon, was the most mobile diazinon residue in all of the soil columns. Between 39 and 53% of the applied radioactivity was found in the leachate as oxypyrimidine. The minor degradate GS-31144 had few detections in the soil column, but comprised 0.9-to-1.8 % of the applied radioactivity in the leachate (MRID 42680901).

(3) Fish bioaccumulation

Diazinon residues (uncharacterized) accumulated in bluegill sunfish exposed to 2 ppb of diazinon, with maximum mean bioconcentration factors of 542x, 583x, and 542x for edible, nonedible, and whole fish tissues, respectively. Depuration was rapid, with 96-to-97% of the accumulated radioactive residues eliminated from the fish tissues by day 7 of the depuration period.

(4) Field dissipation

The registrant conducted twelve terrestrial field dissipation studies. All of these studies are considered to be supplemental because samples were stored frozen beyond the stability of a degradate of toxicological concern; diazoxon is not stable in samples stored frozen for as little as 30 days. Diazoxon, a far more potent cholinesterase inhibitor than diazinon, is an intermediate compound formed by the hydrolysis of diazinon to oxypyrimidine. Under frozen storage, diazoxon degraded to oxypyrimidine. Diazoxon was recovered at trace amounts in four of the twelve studies, but all twelve studies showed diazinon degrading to oxypyrimidine. It is not possible from any of these studies to determine how much diazoxon was present when the soils were sampled. In six of the studies, storage time was not reported; in the other six studies, most samples were stored for longer than 30 days.

Aside from this major flaw in all of the studies, several points can be learned from the information provided by these twelve field studies. There were four studies for each of the three formulations of granular, emulsiable concentrate, and wettable powder. Studies were conducted on corn, citrus, and apples in California, Illinois, Florida, and New York. Each study representing a crop had a companion study with a bareground application in the same area.

- C In eleven of the studies, diazinon dissipated with half-lives ranging from 5 to 20 days.
- C There appeared to be no correlation between formulation type and half-life.
- C Oxypyrimidine was the primary diazinon degradate recovered from all of these studies. It should also be noted that oxypyrimidine is also the result of diazoxon degradation in frozen storage.
- C The leaching potential of diazinon in this study was primarily determined by precipitation amounts and timing. Soil type appeared to be a secondary factor. There may be a slight difference in leaching potential determined by formulation type with the granular formulation having less potential to leach than the emulsifiable concentrate or the wettable powder, but this difference cannot be conclusively defined by the submitted information because of the precipitation differences in the studies.
- C Oxypyrimidine often leached to the lowest depth sampled (48 or 72 inches).
- C Analysis was done for parent and three degradates in these studies: the primary degradate was **oxypyrimidine** referred to as G-27550, the second most common degradate, **GS-31144** was identified as 2-(1-hydroxy-1-methyl ethyl)-4-hydroxy-6-methyl pyrimidine, and the third degradate, referred to as **diazoxon**, is O,O-diethyl-O-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphonate.

GRANULAR FORMULATION

Diazinon dissipated with a half-life of 9 days from the upper 6 inches of test plots of sandy loam soil (series not specified) planted to corn in California. The plots were treated with four weekly applications of diazinon (14% G) at 2.2 lbs ai/A/application (8.8 lbs ai/A total) beginning in May 1988. Diazinon appeared to accumulate as a result of the repeated applications. Diazinon was, in general, not detected below the 0- to 6-inch soil depth. The degradate oxypyrimidine was isolated as deeply as the 12-inch depth, and GS-31144 was detected only to the 6-inch soil depth (Study 1, MRID 41320101).

Diazinon dissipated with a half-life of 7 days from the 6-inch soil depth of bareground plots of loamy sand soil (series not specified) in California treated with diazinon 14-G at 8 lb a.i./A in May 1988. Diazinon was not detected below the 6-inch soil depth. Oxypyrimidine was detected as deeply as the 24-inch soil depth, and GS-31144 was detected as deeply as the 6-inch soil depth (Study 2, MRID 41330102).

Diazinon dissipated with a half-life of 5 days from plots of sandy soil (series not specified) planted to corn in Illinois following the last of four weekly applications of diazinon (14% G) at 2.2 lb ai/A/application (total 8.8 lb ai/A). Diazinon was not detected below the 12-inch soil depth. The degradate oxypyrimidine was detected to a soil depth of 72 inches and the degradate GS-31144 was detected to 18 inches of depth. The maximum length of frozen storage time of soil samples was unreported for this study (Study 6, MRID 41432701).

Diazinon dissipated with a half-life of 6 days from the upper 6 inches of bare ground plots of sandy soil (series not specified) in Illinois that were treated with diazinon (14% G) at 8 lb ai/A. Diazinon was not detected below the 6-inch soil depth with the exception of one isolated sample. The degradate oxypyrimidine leached to 72 inches of depth. Also, the degradates GS-31144 and demethyl oxypyrimidine were detected to 6 inches of depth. The maximum length of frozen storage time of soil samples was unreported for this study (Study 7, MRID 41432702).

WETTABLE POWDER

Diazinon (50 WP) dissipated with a half-life of 6 days from the 0- to 6-inch depth of sandy soil (series not specified) in field plots in a mature citrus grove near Windermere, Florida following the last of five weekly applications (two applications at 3.3 lbs ai/A/application followed by three applications at 5.5 lbs ai/A/application, 23.1 lbs ai/A total) of diazinon (50% WP) made beginning on July 29, 1988. Diazinon was isolated in the 18-to-24 inch depth. The degradate oxypyrimidine was isolated in the 36- to 48-inch soil depth which was the lowest depth sampled. The degradates, GS-31144 and demethyl oxypyrimidine were isolated in the 0- to 6-inch soil depth, and diazoxon was isolated in the 0-6 inch depth and at one interval in the 12- inch soil depth (Study 3, MRID 41320103).

Diazinon (50 WP) dissipated with a half-life of 8 days from the upper 6 inches of bareground plots of sandy soil (series not specified) located near Windermere, Florida, that were treated with a 50% WP formulation at 10 lb ai/A on August 26, 1988. Diazinon was isolated to a depth of 18 inches. The degradate oxypyrimidine was detected at the lowest sampling depth (36- to 48- inches). Other degradates identified were demethyl oxypyrimidine in the top 6 inches and diazoxon which was detected to a depth of 12 inches (Study 10, MRID 41432705).

Diazinon dissipated with a half-life of 10 days from bareground plots of Traver sandy loam soil in a California apple orchard following the last of seven bimonthly 3.3 lbs ai/A applications (23.1 lb ai/A total) of diazinon (50% WP). Diazinon appeared to accumulate between repeated applications. Diazinon was not detected below the 18-inch soil depth. The degradate oxypyrimidine was detected to the depth of sampling (48 inches). The degradates, GS-31144 and demethyl G-27550, leached to the depth of 18 inches. Diazoxon was recovered in the top six inch layer (Study 8, MRID 41432703).

Diazinon dissipated with a half-life of 6 days from the upper 6 inches of bareground plots of Traver sandy loam soil in California that were treated with diazinon (50% WP) at 10 lb ai/A on June 22, 1988. Diazinon and oxypyrimidine leached to 48 inches of depth. The degradates diazoxon and GS-31144 were isolated only in the 6-inch soil depth. The length of sample storage was not reported in this study (Study 9, MRID 41432704).

EMULSIFIABLE CONCENTRATE

Diazinon dissipated with a first order, linear half-life of 20 days (R-square = 0.85) from bareground plots of Delhi loamy sand soil in Reedley, California that were treated with diazinon (4 lbs a.i./gal EC) at 8 lbs a.i./A. Diazinon leached to the 48-inch soil depth (depth of sampling). Oxypyrimidine (G-27550) leached to the 36-inch soil depth. The length of sample storage was not reported in this study (Study 4, MRID 41320104).

Diazinon, dissipated with a half-life of 7 days from the 0- to 6-inch depth of Delhi loamy sand soil in an orange grove in Reedley, California following the last of five applications of diazinon (4 lbs/gal EC) at 3.3-to-5.5 lb a.i./A/application (total 23.1 lbs a.i./A). Diazinon accumulated as a result of the repeated applications. Diazinon leached as deeply as the 36-inch depth. Oxypyrimidine leached to the 36- to 48-inch depth. The degradates diazoxon and GS-31144 leached to the 6- to 12-inch depth; demethyl oxypyrimidine was isolated in the 0- to 6-inch depth. The length of sample storage was not reported in this study (Study 5, MRID 41320105).

Diazinon dissipated with a half-life of 5 days from bareground plots of Berrion fine sandy loam soil near Phelps, New York that were treated with diazinon (48% EC) at 10 lbs a.i./A. Diazinon was not detected below the 12-inch depth. The degradate oxypyrimidine exhibited a greater potential to leach than diazinon and was detected in the 18- to 24-inch soil depth. Other identified degradates were GS-31144 detected in the upper 12 inches and demethyl oxypyrimidine detected in the upper 6 inches of soil (Study 11, MRID 41432706).

Diazinon dissipated with a first order half-life of 17 days from the 0- to 6-inch depth of Berrion fine sandy loam soil in an apple orchard near Phelps, New York, following the last of seven applications of diazinon (48% EC) at 14- to 21-day intervals at 3.3 lbs a.i./A/application (total 23.1 lbs a.i./A). The observed 50% dissipation time was less than one week, but diazinon was at measurable levels in this study until 120 days posttreatment. Diazinon was not detected below the 12-inch depth. Oxypyrimidine and GS-31144 were detected to a soil depth of 6- to 12-inches (Study 12, MRID 41432707).

(5) Spray Drift

No new diazinon spray-drift specific studies were reviewed. However, the registrant is a member of the Spray Drift Task Force which has submitted a series of studies intended to characterize spray droplet drift potential. The Agency intends to evaluate these studies and in the interim is relying on estimated drift rates of 1 percent at the applied spray volume from ground applications and 5 percent from aerial applications at 100 feet downwind of treated sites. After review of the new studies, the Agency will determine whether a reassessment of the potential risks resulting from the application of diazinon is warranted.

WATER RESOURCES ASSESSMENT

The purpose of this water resources assessment is to describe the occurrence of diazinon in water resources of the United States. This information on occurrence is used here to characterize the overall impacts on water quality from the use of diazinon, ecosystem exposure, and potential human exposure to diazinon via drinking water.

There are four major sections of this assessment. First, a summary of major conclusions describing the impact of diazinon use on the quality of ground and surface water resources. The summary is based on an evaluation of environmental fate data, monitoring studies conducted by state and federal agencies, modeling, and compliance information submitted to EPA from wastewater treatment facilities as a result of a permitting process. Second, there is a drinking water assessment describing the process used to estimate diazinon concentrations in drinking water, and uncertainties in our assessment. The third section describes individual monitoring studies and summarizes the results of each study. Monitoring was available to characterize the water quality impact of both agricultural and non-agricultural uses of diazinon (including urban uses, for example homeowner lawn care, pet groomers, kennels, and pest control businesses), and other non-agricultural uses, (for example forestry and rangeland uses); therefore, the monitoring studies are organized into these two categories with an additional category ("mixed") for studies of both agricultural and non-agricultural uses. Air, rain, and fog monitoring is also discussed. The fourth (and final) portion of this assessment summarizes and describes modeling results, which estimate concentrations that can occur in surface water as a result of diazinon use on specific agricultural crops. The modeling results are used to assess risk to aquatic species and are discussed in that context in the ecological risk assessment portion of this document. They have also been used, in part, to set the upper bound on the drinking water exposure estimate.

SUMMARY

The EPA's Office of Water has established an adult Lifetime Health Advisory (HAL) for diazinon of 0.6 $\mu g\ L^{-1}$ but no Maximum Contaminant Level (MCL) has been established. Since drinking water facilities are not required to monitor for diazinon, only limited data were available to directly measure its concentration, or that of a major degradate oxypyrimidine, in drinking water. The Office of Water also establishes criteria as required by the Clean Water Act for the protection of aquatic life. The water quality criteria document for the protection of aquatic life from diazinon residues is in draft form at present, and are not described in this document.

Sources of monitoring data used in this assessment included: United States Geological Survey's (USGS) National Water Quality Assessment (NAWQA) (USGS, 1998) and National Stream Water Quality Network (NASQAN) (USGS, 1999) programs, the Permit Compliance System (PCS) database for National Pollutant Discharge Elimination System (NPDES) permits (USEPA, 1998), National Survey of Pesticide in Drinking Water (NPS) (USEPA, 1990), several states**,** and the open literature**.** The data reviewed in this assessment vary in quality, but are generally high overall, based on:

QA/QC procedures, analytical methods, and field techniques. Contextual information on diazinon usage history in the areas monitored is, however, often quite limited.

Major Conclusions

Non-agricultural uses of diazinon, including homeowner uses, appear to have significantly affected both surface- and ground-water quality.

A major conclusion of USGS NAWQA program scientists is that urban use of diazinon has affected surface water quality in non-agricultural areas and is found more frequently and at higher concentrations in urban than in agricultural streams. Based on locations where ten or more samples were collected, 65.6% of surface-water samples in non-agricultural use-areas contained diazinon compared with 26.2% of the samples in agricultural areas (Table 7). While the peak concentrations reported were similar in non-agricultural and agricultural areas (2.90 and 3.80 : g/L, respectively), the 95th percentile concentration in the streams in non-agricultural areas was more than five times higher than in agricultural areas (0.28 : g/L and 0.052 : g/L, respectively). The NAWQA program limit of detection of diazinon is 0.002 : g/L.

In an analysis of pesticides in streams draining relatively small basins where pesticide use could be characterized as agricultural (40 streams) and urban (11 streams), NAWQA scientists reported that 16.9% of samples in agricultural areas, and 75% of samples in urban areas contained diazinon (Table 9). The 95th percentile concentrations at urban and agricultural sites were 0.43 : g/L (peak concentration of 1.9 : g/L) and 0.027 : g/L (peak concentration of 1.2 : g/L), respectively. NAWQA scientists noted that a distinctive feature of urban streams was the common occurrence of mixtures of both herbicides and insecticides. More than 10 percent of the urban stream samples contained a mixture of at least four herbicides plus diazinon and chlorpyrifos.

The following are examples of diazinon impacts on urban surface-water quality in several states:

C **California: Castro Valley Creek Watershed**: A study was conducted during the 1995-96 and 1996-97 rainy seasons (October - May) in the Castro Valley Creek watershed to determine the temporal and spatial variability of diazinon in surface water and the sources of diazinon in the watershed. Land use in this relatively large urban watershed was 50% residential and 15% commercial (35% undeveloped). Diazinon concentrations streams in the watershed appeared to peak in the spring and fall and, therefore, correlated with application patterns in urban areas. The largest diazinon detections occurred in runoff following extended dry periods. Diazinon was detected in *all* of the 42 samples collected near the mouth of Castro Valley Creek in the two years of monitoring (Table 17). A second study of the Castro Valley Creek watershed (Table 18) was conducted to evaluate diazinon impacts in subcatchments. Monitoring at the discharge points of each subcatchment, indicated that those with the largest areas of undeveloped land had the smallest diazinon concentrations. In this study, roughly 80% of the samples collected in each subcatchment contained diazinon.

C **California: three residential sites**: In the Castro Valley Creek watershed and in Oakland a residential runoff study was conducted to determine the concentrations of diazinon in rainfall and runoff resulting from ant control treatments. Water samples were collected from gutters, patios, roof drains, driveways, and rainfall at three residential sites. Diazinon was detected in 100% of the samples, and was found as long as seven weeks after application. Concentrations in the rainfall itself ranged up to 1.3 : g/L; in the other samples of runoff collected adjacent to treated areas, diazinon concentrations were reported up to 1,200 : g/L (Table 19). In this study, diazinon was applied at 2/3 the normal application rate for ant control; thus, the reported concentrations resulted from this reduced application rate.

C **Colorado**: A study conducted in Colorado confirms the NAWQA findings that urban uses tend to have higher frequencies of detection of diazinon than agricultural uses. Diazinon was detected more often in urban surface water samples (72%) than in agricultural surface water samples (24%), as shown in Table 13. Higher concentrations were measured in the May through September time-period.

C **Washington**: In King County, Washington, a recent study conducted in April and May of 1998 showed that diazinon was detected in nine out of 10 urban streams. Although these samples do not represent a long-term concentration, diazinon concentrations in all but one of the streams exceeded California standards for long-term exposure of aquatic life. Concentrations ranged up to 0.425 : g/L. All of the detections are believed to be linked to homeowner lawn care practices.

A total of 3,023 ground-water sites (each site sampled once) were analyzed by the US Geological Survey's (USGS) National Water Quality Assessment (NAWQA) program from both agricultural and non-agricultural sites. Overall, 1.69% of the ground-water samples contained diazinon. As seen in Table 3, diazinon was found more often in shallow ground water (less than 10 years old) in urban areas than agricultural settings, reported in 1.66% versus 0.5%. The magnitude of the concentrations was low overall with a maximum concentration of 0.077 : g/L in agricultural areas and 0.01 : g/L in urban areas.

Monitoring data indicate widespread occurrence of diazinon in surface water nationally.

Diazinon was the most frequently detected insecticide in surface water in the NAWQA program. Diazinon has been measured in surface water in 24 states plus Washington, DC. In addition, wastewater treatment facilities in 14 states (six additional states) have reported high concentrations of diazinon in effluent discharged to surface water.

A total of 1,058 surface water sites and 5,155 samples were analyzed by the US Geological Survey's (USGS) National Water Quality Assessment (NAWQA) program from both agricultural and non-agricultural sites. Though the NAWQA program did not specifically target diazinon use areas, 35% of the surface water samples collected contained diazinon, with a peak concentration of 3.8 :g/L (Table 6). In an analysis of a subset of data NAWQA believed to best represent land use, three out of four samples from urban streams contained diazinon residues. As part of this analysis, NAWQA collected samples at 14 "integrator" sites from large streams and rivers that drain relatively large basins in which pesticide use, soils, and land use are heterogeneous. NAWQA scientists reported that 45% of samples, or almost one out of every two samples contained diazinon (Table 10**)** at concentrations up to 0.40 :g/L. The 95th percentile concentration calculated by NAWQA was 0.073 :g/L.

Diazinon was detected in every major river basin, including the Mississippi, Columbia, Rio Grande, and Colorado, in the USGS NASQAN study (Table 11) diazinon was detected in 33% and 26% of the samples from the Rio Grande and Mississippi rivers. These rivers drain a significant portion of the US. The limit of detection for diazinon in the NASQAN study was 0.002 :g/L.

Diazinon is widely used in California and, for this reason, a great deal of surface water monitoring has been conducted by several agencies from 1992 to 1998. To date, diazinon has been detected in the San Joaquin River, the Sacramento River, the Merced River, Russian River, the Tuolumne River, Orestimba Creek, and the Stanislaus River.

Diazinon residues have been found in large rivers and major aquifers.

Major rivers: The USGS National Stream Water Quality Network (NASQAN) program monitors water quality in the Nation's largest river basins. Diazinon was detected (1995-1998) in all of the major rivers in NASQAN including the Rio Grande, Mississippi, Columbia, and Colorado and in 33%, 26%, 7%, and 7% of the samples, respectively. From hundreds of samples collected (Table 11), concentrations ranged up to 0.207 :g/L using a detection limit of 0.002 :g/L. That diazinon is found in these large rivers is extremely important. Because the volume of water flowing in these rivers is very large, the low pesticide concentrations reported result in a high total mass of diazinon transported in these rivers.

It is significant that NAWQA data confirm the NASQAN findings for large streams and rivers. In an analysis of a subset of data NAWQA believed to best represent land use, NAWQA collected samples at 14 "integrator" sites from large streams and rivers that drain relatively large basins in which pesticide use, soils, and land use are heterogeneous. NAWQA scientists reported that 45% of samples, or almost one out of every two samples contained diazinon (Table 10) at concentrations up to 0.40 :g/L. The 95th percentile concentration calculated by NAWQA was 0.073 :g/L.

Major aquifers: Data from the USGS NAWQA program reported a 1.82% detection frequency of diazinon in major aquifers, with a maximum concentration of 0.085 :g/L. Major aquifers are defined as those that are major current or future sources of ground water supply within a specific hydrogeologic region. Samples are collected from these aquifers from large drinking water supply wells (production wells) (Table 4). Among the set of pesticides that NAWQA looked at, diazinon is one of the two insecticides found in these major aquifers (the other is carbaryl). All of the other pesticides found were herbicides (10 of them including atrazine and its degradation product deethylatrazine (DEA), metolachlor, cyanazine, alachlor, bentazon, simazine, prometon, diuron, and tebuthiuron). While there was a low rate of false positives for diazinon in the ground-water program (see NAWQA ground water summary below), the number of detects is substantially more than could be accounted for by the false positive rate.

Diazinon was detected in drinking water wells in Missouri (1987-88), Mississippi (1983-84), Virginia (1989-90) (Tables 20, 21, 22). In all three of these states, the detections occurred in wells located in agricultural areas. Diazinon residues were found in deep wells in both Missouri (average of 81 feet) and Virginia (average of 200 feet), indicating that residues may be transported to relatively deep ground water. The highest concentration seen in these wells was 1.00 :g/L

The properties of diazinon degradates suggest that they can significantly impact water resources; however, no monitoring data are available for these compounds. Monitoring for other pesticides indicates that overall occurrence and concentrations of pesticides in ground water is significantly underestimated when degradates are not evaluated in addition to parent compounds.

Many wastewater treatment facilities in 14 states are out of compliance with the Clean Water Act as a result of diazinon residues in effluent.

All facilities where water is discharged directly into surface waters must obtain a permit through the National Pollutant Discharge Elimination System (NPDES) to be in compliance with the Clean Water Act. The EPA's Office of Water is presently writing the water quality criteria document for the protection of aquatic life from diazinon residues. Both acute and chronic protection limits for fresh and saltwater species are being developed. The acute number are almost final but there is a additional work needs to be done for the chronic numbers.

The EPA's Permit Compliance System (PCS) is a national database of NPDES data that tracks permit issuance, permit limits, and monitoring data for over 64,000 regulated facilities. Toxicity tests conducted at 16 of these facilities failed because of the presence of diazinon. Diazinon was detected in 52% of the influent samples and 40% of the effluent samples from these facilities between 1994 and 1998. Maximum concentrations were 11.0 :g/L and 10.0 :g/L for the influent and effluent samples, respectively (Table 14).

A nationwide survey, conducted by the National Effluent Toxicity Assessment Center (NETAC) to determine the occurrence of diazinon in the effluent from wastewater treatment facilities (sometimes referred to as publicly owned treatment works or POTWs) showed that 65% of the samples contained diazinon residues (Table 15).

A total of 47 facilities across the US have failed toxicity tests because of diazinon in their effluent. Below are examples of monitoring at wastewater treatment facilities in several states:

- **Texas.** Diazinon has caused wastewater treatment facilities to fail toxicity tests in eight large municipal systems including the Cibolo Creek Municipal Authority (City of Denton), City of Big Spring, City of Greenville, City of Fort Worth, City of Temple, City of Tyler, and the Trinity River Authority.

- **California.** In 1996, The California EPA and the Contra Costa Sanitary District conducted a study in Contra Costa, Alameda, and Santa Clara counties, California to determine the load of diazinon and chlorpyrifos in wastewater in residential areas, at commercial sites, and in influent to three wastewater treatment facilities. Diazinon was detected in 83% of the samples from the residential areas (constituting 82% of the load to the treatment facility) at concentrations up to 4.30 μg/l. The detection limit of diazinon was 0.05 μg/l. Diazinon was detected in 53% of the samples from nine of the 12 commercial sites tested, which included pet groomers, kennels, and pest control businesses. The largest diazinon concentration of 20.0 μg/L was detected in the wastewater from a kennel. Diazinon was detected in 100% of the samples from all three treatment plants at concentrations ranging from 0.066 to 0.940 μg/L (Table 16).

- **Florida.** Diazinon use by professional lawn care applicators (approximately 200,000 pounds) is higher in Florida than anywhere else in the US. In Florida, whole effluent testing is done for wastewater treatment facilities to detect toxicity from a mixture of chemicals, including diazinon. Concern for diazinon in effluent from these facilities occurred as early as 1988; however, within the past five years the State has recognized an increasing occurrence of diazinon-related toxicity in analyses of effluent. To date, diazinon has been detected in approximately 21 facilities at concentrations ranging up to 1.57 μg/L.

- **Oklahoma.** Four large wastewater treatment facilities have consistently failed toxicity tests from 1996 to 1998. The Oklahoma Department of Environmental Quality (DEP) believes that spring and summer lawncare applications are the cause of the diazinon residues in the wastewater. Because of these failures, USEPA's Region 6 required the facilities to conduct an educational campaign on diazinon use. Oklahoma does not treat their effluent to remove diazinon because it is too costly.

Diazinon has been measured in air, rain, and fog.

Diazinon is one of the most common organophosphate compound detected in air, rain, and fog (others include methyl parathion, parathion, malathion, chlorpyrifos, and methidathion). In the 1970's, diazinon was detected throughout the US. Since then, most sampling and analyses have been done in California fog and air.

Air. In 1971, diazinon was detected in approximately 80% of the sites sampled nationally. Over 60% of these sites also contained diazoxon. By 1988, sampling was done only in California. Diazinon and diazoxon were detected in approximately 90% and 85% of the sites sampled. A 1976 study indicated that there was a strong correlation between high air concentrations, regional use, and cropping patterns. Concentrations of diazinon in air range from 0.0011 to 306.5 ng/cubic meter; for diazinon-OA they range from 0.0014 to 10.8 ng/cubic meter.

Recent USGS monitoring also indicates that diazinon is being found in Sacramento urban air samples as well as samples taken in agricultural areas upwind and downwind of the urban site. The USGS conducted a study to monitor the occurrence, concentration, and geographical distribution of agricultural pesticides in air over the Mississippi River. Diazinon was detected in all of the samples (100%) at concentrations ranging from 0.04 to 0.36 ng/m^3. The highest concentrations of diazinon, chlorpyrifos, and malathion were observed near major metropolitan areas where agricultural use of these chemicals was minimal.

Rain. Rain has not been analyzed for pesticides as often or at as many sites as air. Concentrations of diazinon in rain ranged from 1.3 to 2,000 ng/L; for diazoxon they ranged from 1.3 to 115.8 ng/L (Majewski and Capel, 1995). More recent monitoring (April-September 1995) has been conducted by the USGS in the Mississippi River valley. Five insecticides, including diazinon, were frequently detected. In two of the three urban sites, significantly more diazinon was detected in the rainfall than at the agricultural sites.

Fog. Of the 48 pesticides that have been detected in fog, only diazinon was near or exceeded the human health limits for drinking water in 5 of 24 fog events (Majewski and Capel, 1995). Concentrations of diazinon in fog were measured as high as 76,300 ng/L; for diazoxon they range up to 28,000 ng/L.

Environmental fate data predicted that water contamination would occur from diazinon use.

The environmental fate characteristics of diazinon suggest that it will occur in both ground and surface water to varying degrees. Diazinon is only moderately mobile (Kds range from 3.7 to 11.7) and is persistent (aerobic soil metabolism half-life of 38 days). Laboratory data also suggest that diazinon will not persist in acidic waters. However, in neutral and alkaline waters residues are quite persistent.

Laboratory data indicate that oxypyrimidine (G-27550), a major degradate of diazinon, is likely to leach in vulnerable environments and would probably be found in ground water at much higher levels than parent diazinon. No monitoring information is available for this major diazinon degradate.

Dormant spray use of diazinon has resulted in surface-water contamination in California.

Diazinon is applied as a dormant spray to orchard crops in California's Central Valley. Several studies have shown that diazinon is not detected in any of the surface water samples collected prior to application (which usually occurs during the winter). However, despite lower than normal application rates, diazinon has consistently been detected in several creeks and rivers in the Sacramento River watershed and the San Joaquin River watershed during the winter rainy season. Diazinon was detected during the winters after application occurred from 1991 through 1998. Diazinon was detected in 5% to 100% of the samples from a variety of locations using diazinon as a dormant spray. Concentrations were very high and ranged up to 36.8 µg/L. A USGS study also concluded that diazinon was found in urban storm runoff because of applications of dormant agricultural sprays in Modesto, California (Tables 12, 23, 26-31).

Lack of good usage data, especially for non-agricultural uses, makes it difficult to know the real impact of diazinon use on water resources.

The diazinon use information is incomplete (especially non-agricultural use) and at too coarse a scale to identify potentially exposed populations with any certainty. If this information was available, vulnerable drinking water sources could be identified. Surface and ground water residues could be significantly higher than in data currently available if monitoring was targeted to those areas where high diazinon usage is known to occur.

Targeting water monitoring in diazinon use areas is especially difficult because of its fragmented use pattern. Major agricultural crops tend to be treated with diazinon only occasionally; non-agricultural use is primarily by very small users and is largely undocumented. Despite the fact that none of the studies reviewed in this assessment were targeted to diazinon use areas, diazinon was still detected in surface water in surprising frequency.

Limited data indicate that diazinon has been found in drinking water reservoirs. Since the EPA has not established an MCL for diazinon, water supply utilities nationwide do not routinely analyze drinking water for diazinon. Preliminary results in the USGS Pilot Resevoir Monitoring Study show that diazinon is frequently found in drinking water resevoirs at concentrations up to 110 ng/L. It was not found in finished water from the same resevoirs, but the samples were not analyzed for either diazoxon or oxypyrimidine.

Monitoring studies must be carefully designed in relation to pesticide application and runoff events in order to adequately characterize occurrence.

The concentrations of diazinon found in surface water are directly related to the frequency and timing of monitoring in relation to pesticide application and storm runoff events. This is demonstrated by numerous studies that have been conducted in the Central Valley of California, particularly those that characterize the impact of diazinon used as a dormant spray. Diazinon was not detected pre-application, but was correlated with rainfall events. The frequency and concentration of diazinon may have been reduced as a result the sampling design as by well as flood events. Studies that demonstrate this include: Sacramento River Watershed (1996-7) and (1997-8); San Joaquin watershed 1997 and 1998. Future monitoring study designs must take this into account in order to accurately assess acute, short-term exposure.

DRINKING WATER EXPOSURE ASSESSMENT

Using monitoring and modeling data, acute and chronic concentrations of diazinon in drinking water were estimated for both surface water and ground water. Since more monitoring information is available for surface water, it was possible to estimate concentrations in both agricultural and non-agricultural use areas. For surface water, a range of values is presented with the lower end of the range derived from monitoring data and the upper end of the range derived from modeling data. The lower end of this range represents the *minimum* exposure expected; the upper end of the range represents the maximum exposure estimated from modeling. Because of limited diazinon use data, especially for non-agricultural uses, diazinon exposure is likely to be higher in some areas than is indicated by the monitoring data. There is also uncertainty in the model estimates, as the models used have not been field validated.

<u>Acute concentrations of diazinon in drinking water</u>

Surface Water. Acute concentrations of diazinon in surface water are presented as a range of values rather than a discrete value. The lower concentration was derived from monitoring data; the upper concentration was derived from modeling. Monitoring data underestimates the peak exposure because of the following sources of uncertainty:

- The percentage of each county (Merced, Sacramento, San Joaquin, Stanislaus) treated with diazinon in the sampled watersheds during the majority of the sampling periods (dormant spray period: December thru March) was estimated to be less than one percent.

- There is a lack of monitoring data in the majority of diazinon use areas (both agricultural and non-agricultural).

- The concentrations of diazinon found in surface water are directly related to the frequency and timing of monitoring in relation to pesticide application and runoff events.

<u>Monitoring</u>**:** There were 98 agricultural and 26 non-agricultural sites where samples were collected from surface waters that were potential drinking water sources (rivers, streams, etc.). The maximum measured value of the diazinon concentration was recorded at each monitoring site. The lower bound on acute exposure was estimated by aggregating the maximum values measured in each study (separating out agricultural and non-agricultural studies), and using the 95th percentile value.

<u>Modeling</u>**:** Because of the uncertainties noted above, we estimated an upper bound acute exposure value from the modeling data. The recommended EEC's for modeling are based on peaches grown in Peach County, Georgia, which has the greatest acreage of peaches in Georgia. PRZM/EXAMS modeling was done using the Index Reservoir to represent upper bound exposure for surface-water sourced drinking water facilities. The one-in-ten-year peak value (or 90th percentile value) was 70.1 :g L^{-1}. A complete description of the methodology used to generate the estimates is in Appendix C . The same value (70.1 :g L^{-1}) was used for the non-agricultural use upper bound acute exposure value for two reasons: (1) because we do not have the tools to model non-agricultural use exposure and (2) the results of modeling for this agricultural use are likely to provide a conservative estimate of the non-agricultural upper bound acute exposure as a result of the heavier non-agricultural loading to the watershed. There are two pieces of information that support this. USGS NAWQA data (for locations with ten or greater samples) show that the percent detects from non-agricultural use areas was 65.6% and that from agricultural use areas was 26.2%. Second, the non agricultural use of diazinon constitutes roughly three-quarters of the overall diazinon use. There is still a significant potential for underestimation of maximum acute exposure to diazinon from surface water drinking water sources because of the limited monitoring and usage data, especially in non-agricultural use areas.

Groundwater: Acute concentrations of diazinon in ground water are presented as a discrete value, because, although significant uncertainties exist in monitoring data, acceptable modeling tools are not yet available. The acute diazinon concentration in groundwater has a high degree of uncertainty in capturing the maximum exposure to diazinon from groundwater drinking water sources because of the lack of monitoring data in the majority of diazinon use areas and the lack of modeling data to place an upper bound on the potential exposure.

Monitoring: The monitoring data for groundwater is much more limited than for surface water. There are only three studies other than the USGS NAWQA data. All the studies were from agricultural use areas except a fraction of the USGS NAWQA data. The NAWQA groundwater data had 0.7% detects in the field blanks spiked with diazinon and the total percent of detects for the environmental samples was 1.8. With this limited data set the acute exposure value calculated from the 95th percentile of the maximum values (same method as for the surface water) is below the detection limit of 0.02 µg/L. This values is used to represent the minimum diazinon concentration in groundwater. Ground-water monitoring from NAWQA is not targeted to diazinon use, and can be expected to underestimate actual peak concentrations. Since there is no approved Tier II model for estimating groundwater concentrations at this time, screening level SCI-GROW model estimates are used to represent the maximum concentration in ground water.

No monitoring data have been collected for either oxypyrimidine or diazoxon in groundwater. It is known that degradates have had significant impacts on ground-water quality for other pesticides with similar environmental fate profiles.

Chronic concentrations of diazinon in drinking water

Surface Water: The 95th percentile of the arithmetic means of all samples at each site (detects and non-detects) from monitoring studies whose samples were from potential drinking water sources was used for the lower bound chronic concentration. Samples with values below the LOD were given a value of one-half the LOD. The same logic was used to calculate the upper bound chronic concentration as was used for the upper bound acute concentration (described in the surface water acute section above). Providing an upper and lower chronic concentration from the available monitoring and modeling data reduces the uncertainty somewhat, but the lack of monitoring data in the majority of the diazinon use areas still means that the maximum chronic concentration may be greater than the estimated value.

Groundwater: The chronic concentration estimate for groundwater was the same as that used for the acute estimate. Groundwater velocity is small compared to surface water and physicochemical processes result in pesticide plumes that can potentially have relatively uniform concentrations. Concentrations measured at a well may show only small fluctuations in concentration especially as the sampling point distance from the pollution source increases. Again, this estimate may not be representative of actual maximum chronic concentrations because of the limited data set and the lack of an upper bound estimate from Tier II modeling data.

Table 1. Estimated diazinon exposure (:g L^{-1}) in drinking water

Type	Acute (monitor/model)	Chronic (monitor/model)

Surface Water Agricultural Use Non-Agricultural Use	 2.3 -70.1 3.0 -70.1	 0.19 -9.4 0.46 -9.4
Ground Water	<0.002 - 0.8	<0.002 - 0.8

MONITORING STUDY SUMMARIES

This section describes individual monitoring studies and summarizes the results of each study. Monitoring was available to characterize the water quality impact of both agricultural and non-agricultural uses of diazinon (including urban uses, for example homeowner lawn care, pet groomers, kennels, and pest control businesses), and other non-agricultural uses, (for example forestry and rangeland uses); therefore, the monitoring studies are organized into these two categories with an additional category ("mixed") for studies of both agricultural and non-agricultural uses. Substantially more monitoring data were available for surface-water than for ground-water resources.

Data Sources and Considerations

There is a range of sources for diazinon monitoring information with variable data quality. Sources used in this assessment included: United States Geological Survey's (USGS) National Water Quality Assessment (NAWQA) (USGS, 1998) and National Stream Water Quality Network (NASQAN) (USGS, 1999) programs, the Permit Compliance System (PCS) database for National Pollutant Discharge Elimination System (NPDES) permits (USEPA, 1998), National Survey of Pesticide in Drinking Water (NPS) (USEPA, 1990), several states, and the open literature.

When reviewing the data the following should be considered:

- All of the data are from studies that did not specifically target diazinon as a contaminant. Therefore, these studies do not directly relate diazinon use with concentrations in surface water or ground water.

- The amount of background and site characterization information varied greatly between studies. This information is critical in determining the relevance of the study results to human exposure to diazinon in drinking water.

- The limit of detection (LOD) for the analytical techniques used to quantify diazinon concentrations in the monitoring samples varied between studies. This directly impacts detection frequencies and should be considered when comparing the results from different studies.

MIXED USE MONITORING STUDY SUMMARIES

US Geological Survey's National Water Quality Assessment Program (NAQWA). The NAWQA program was designed to describe the status and trends of a representative portion of the nation's water quality and to provide a sound scientific understanding of the primary natural and human factors affecting the water quality (Hirsch et al., 1988). The NAWQA program is an aggregation of some 60 regional study units, which are monitored on a rotating schedule to take into account long-term variations in water quality. NAWQA study units are geographically defined by a combination of ground- and surface-water features and usually encompass more than 10,000 square kilometers.

The USGS Pesticide National Synthesis Project provides the following considerations for data interpretation:

> The NAWQA program is based on a complex sampling design that targets specific land use and hydrologic conditions in addition to assessing the most important aquifers and streams in each area studied. Although studies in each NAWQA study unit have some common design elements, they are not specifically designed to produce a statistically representative analysis of national water-quality conditions, especially with results only from the first 20 study units.
>
> For both streams and ground water, a major component of the sampling design is to target specific watersheds and shallow ground water areas that are influenced primarily by a single dominant land use (agricultural or urban) that is important in the particular area. This component of the design facilitates the summary of results by agricultural and urban land use settings, but results require careful interpretation.
>
> The NAWQA design does not result in an unbiased representation of all streams or shallow groundwater in agricultural settings. For agricultural land use, the focus was limited to the most important agricultural settings within the first 20 study units. Thus, some agricultural activities and related pesticide use that may be very important in a particular part of the nation are not included. For example, the 20 study areas did not include intensive rice growing areas. On the other hand, a particular pesticide may be important in one or two of the 20 study units, but not in the others, and the averaged results may be misleading in this regard. Another possibility is that use of a particular pesticide is much greater than average in the watersheds and groundwater areas studied, leading to an overestimate of occurrence and concentrations relative to other areas. Similar biases are possible for urban areas as well, but the dominant pesticides used are probably more similar among urban areas than they are among agricultural areas with different crops.

For both streams and groundwater, statistical summaries for "agricultural" and "urban" land uses and for "major streams" and "major aquifers" were prepared by the USGS from a carefully selected subset of the complete NAWQA data set in order to control or minimize biases due to different temporal sampling strategies and special studies. They state that "The summaries are designed to give a broad and averaged perspective on national results." The criteria for data selection are described below for ground water and surface water, separately.

Although the quality of the NAWQA data is excellent, the program was not designed to target diazinon (or other pesticide) use areas and, therefore, the overlap between the NAWQA sampling sites and use areas for diazinon is largely unknown (Figures 1 and 2). NAWQA data are available via the Internet at http://water.wr.usgs.gov/pnsp/allsum/.

Ground Water

The USGS generated statistical summaries of the ground-water data for three different settings: shallow ground water in primarily agricultural areas (Table 3), shallow ground water in primarily urban areas (Table 3), and major aquifers (Table 4). The agricultural and urban land-use categories were represented by wells chosen or designed to sample shallow, recently recharged ground water to determine the effects of specific land uses on water quality. Sites comprising the "major aquifer" category had no such restrictions on land use or water age, and thus, represent a broader mixture of land uses and ground water depths.

Table 2 summarizes data for every NAWQA ground-water sample that was analyzed for pesticides, including newly drilled monitoring wells, production wells (such as domestic and public-supply wells), springs, and tile drains. Although Table 2 provides a complete summary of all NAWQA results, it should not be presumed to be a statistically representative summary of the NAWQA pesticide results. The data in the table contain a variety of spatial and temporal biases for which corrections must be applied before any reliable statistical summaries can be compiled. For example, many of the sites were sampled more than once for pesticides. Failure to account for this would lead to an over-representation of these sites in any statistical summary of chemistry data in which they were included.

The USGS followed the following procedures to generate the relatively unbiased and comparable statistical summaries using data from NAWQA ground-water sampling networks presented in Tables 2 and 3:

(1) Tile drains and springs were excluded to reduce the variability in site type.

(2) Any well co-located with another existing well was excluded (to examine the effects of well depth or well type, for example). Thus, the networks albelus2, gafllusur3b, sanjlus42, sanjlus52, sanjlus62, trinlusur2, and trinlusur3 were excluded.

(3) Networks with fewer than 10 wells were excluded because they contained an insufficient number of wells to be spatially representative of an area.

(4) Wells that were included in more than one type of network (e.g. a land-use study and an aquifer survey) were allowed to exist in both.

(5) One sample from each well was selected. Generally this was the first sample collected.

Samples were collected between 6/30/92 and 11/15/96. The LOD for diazinon was 0.002 µg L^{-1}. No degradates were analyzed.

Table 2. Results (µg L^{-1}) from the USGS NAWQA monitoring program for all wells sampled

Wells	Samples	Detects	Range[1]	Mean	95^{th} Percentile	Median
2616	3023	51	0.160 - ND[2]	0.014	ND	ND

[1] Range, mean, median and 95^{th} percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.
[2] Below the LOD.

Table 3. Results (µg L^{-1}) from the USGS NAWQA monitoring program for shallow ground water

Land Use	Wells	Samples	Detects	Range[1]	Mean	95^{th} Percentile	Median
Urban	301	301	5	0.010 - ND[2]	NR[3]	ND	NR
Agricultural	924	924	5	0.077 - ND	NR	ND	NR

[1] Range and 95^{th} percentile are determined from all samples.
[2] Below the LOD.
[3] Not Reported.

Table 4. Results (µg L^{-1}) from the USGS NAWQA ground-water monitoring program for major aquifers.

Wells	Samples	Detects	Range[1]	Mean	95^{th} Percentile	Median
933	933	17	0.085 - ND[2]	NR[3]	ND	NR

[1] Range and 95^{th} percentile are determined from all samples.
[2] Below the LOD.
[3] Not Reported.

Surface Water

Table 5 summarizes results from all NAWQA sites where streams were sampled for pesticides. These include sites sampled many times over several years, as well as sites sampled only once or twice. The results summarized in Table 5 are from all stream samples, including samples collected on a fixed sampling frequency, high flow samples, low flow samples, diurnal and storm hydrograph samples, and samples collected as part of special synoptic studies. Because all sites and all samples are included, the summary statistics shown in Table 5 are likely to be biased. For most compounds, the detection frequencies and concentration percentiles shown will be biased high for commonly occurring conditions because more samples were collected at sites where concentrations were high, or samples were collected more frequently during periods of elevated concentrations. For some compounds, on the other hand, the values shown may be biased low because sampling was not conducted during high-use periods. The maximum concentrations shown in Table 5 are the highest concentrations observed in all NAWQA stream samples. Table 5 should not be presumed to be a statistically representative summary of the NAWQA pesticide results. Samples were collected between 4/20/92 and 12/16/96. The LOD for diazinon was 0.002 µg L^{-1}.

Table 5. Results (µg L^{-1}) from the USGS NAWQA surface water monitoring program.

Land Use	Sites	Samples	Detects	Range[1]	Mean	95th Percentile	Median
Agricultural	507	2977	703	3.80 - ND[2]	0.017	0.042	ND
Non-Agricultural	551	2178	1095	2.90 - ND	0.050	0.240	0.003

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.

[2] Below the LOD.

Table 6. Results (µg L^{-1}) from the USGS NAWQA surface water monitoring program for agricultural land use monitoring sites where pesticides are used.

Sites	Samples	Detects	Range[1]	Mean	95th Percentile	Median
381	1989	544	3.80 - ND[2]	0.023	0.075	ND

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.

[2] Below the LOD.

We selected a subset of the NAWQA surface water data for analysis using only sites at which at least ten samples were collected. Because of the high temporal variability of surface water concentrations, it was felt that this dataset would more accurately represent pesticide concentrations in surface water. These data are presented in Table 7.

Table 7. Results (µg L^{-1}) from the USGS NAWQA surface water monitoring program for sites with ten or more samples.

Land Use	Sites	Samples	Detects	Range[1]	Mean	95th Percentile	Median

Table 7. Results (μg L^{-1}) from the USGS NAWQA surface water monitoring program for sites with ten or more samples.

Agricultural	59	2183	572	3.80 - ND[2]	0.019	0.052	ND
Non-Agricultural	31	1161	762	2.90 - ND	0.065	0.280	0.011

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD. [2] Below the LOD.

Linear regression was used to relate the concentration results for sites with ten or more samples to pesticide use for the period 1992-97, and to several physicochemical parameters of the sampled surface waters. There were 36 sites that had agricultural land use classifications and diazinon use. Separate regressions were calculated for each predictor (independent variable). The table below gives the p-value and r^2 for each predictor. These statistics can be interpreted as follows: r^2 gives the proportion of variance of concentration explained by a linear relationship with a given predictor. The value of r^2 will be between zero and 1, with larger values indicating more variability explained. The p-value is used to assess whether or not an apparent relationship (as measured by r^2 or the regression slope) can be attributed to variability in the data (Table 8).

According to the conventional criterion of statistical significance (p-value at or below 0.05), none of the regressions are significant except for the relationships with specific conductivity and dissolved oxygen. For both regressions the slopes were negative. However, the low value of r^2 indicates that the relationship is weak in terms of the fraction of variation in concentration that can be explained by variation in specific conductivity or dissolved oxygen.

Table 8. Results from the regression analysis of diazinon concentration against (1992-97) diazinon use and physicochemical parameters of the sampled surface waters.[1]

Regressed Parameters	r^2	p-value
Diazinon Conc. vs Use	0.014	0.49
Diazinon Conc. vs pH	0.018	0.44
Diazinon Conc. vs Streamflow	7.4×10^{-4}	0.87
Diazinon Conc. vs Temp.	9.7×10^{-3}	0.57
Diazinon Conc. vs Specific Conductivity	0.41	2.7×10^{-5}
Diazinon Conc. vs Dissolved Oxygen	0.31	4.7×10^{-4}

[1] All regressions calculated using mean values. Non-detects were given a value of one-half the LOD. Agricultural use data for 1992-1997 from Doanes Marketing Research, Inc.

USGS scientists identified several subsets of sampling locations they believe to characterize agricultural, urban, and mixed land uses. Tables 9 and 10 summarize the results of NAWQA sampling for pesticides in streams draining relatively homogenous basins that represent specific agricultural and urban land uses (indicator sites) and streams draining large basins with mixed land uses (integrator sites). The summaries in Tables 9 and 10 are based on samples collected during a one-year period at 65 sites located on streams within the first 20 NAWQA study units. Table 9 summarizes results from 40 streams with primarily agricultural basins. These agricultural indicator sites have relatively small basins (27 to 6000 sq km, with most less than 1000 sq km) and include a variety of different crop types and agricultural practices. Table 17 summarizes results from 11 streams with primarily urban basins. These urban indicator sites have small basins (25 to 108 sq km) in which the primary uses of pesticides are non-agricultural. Table 10 summarizes results from 14 integrator sites on large streams and rivers that drain relatively large basins (1800 to 92000 sq km) with heterogeneous land use, diverse soil types and topography, and usually a variety of pesticide uses. Samples were collected throughout the year at most of the 65 sites included in Tables 9 and 10.

Not all samples collected during the year at each site were used in the USGS calculation of the summary statistics, however. Samples collected as part of a fixed-frequency sampling schedule were included, along with a much smaller number of samples collected during selected high or low flow conditions. Samples collected over a storm hydrograph, or as part of a study of diurnal variability, were excluded in order to avoid bias resulting from repeated sampling during extreme conditions. The sampling frequency at most sites was higher during periods of the year when pesticide concentrations were expected to be elevated, so that the detection frequencies and concentration data shown may be somewhat higher than would be obtained from samples evenly distributed throughout the year. At most sites, 1 to 2 samples were collected each month during periods when pesticide transport in the streams was expected to be low. Sampling frequency increased to 1 to 3 samples per week during periods when elevated levels of pesticides were expected in the streams.

Table 9. Results ($\mu g\ L^{-1}$) from the USGS NAWQA surface water monitoring program for 40 agricultural and 11 urban sites.

Land Use	Sites	Samples	Detects	Range[1]	Mean	95th Percentile	Median
Urban	11	326	244	1.90 - ND[2]	NR[3]	0.430	NR
Agricultural	40	1000	169	1.20 - ND	NR	0.027	NR

[1] Range and 95th percentile are determined from all samples.
[2] Below the LOD.
[3] Not Reported.

Table 10. Results ($\mu g\ L^{-1}$) from the USGS NAWQA surface water monitoring program for 14 integrator sites on large streams and rivers.

Sites	Samples	Detects	Range[1]	Mean	95th Percentile	Median
14	245	111	0.40 - ND[2]	NR[3]	0.073	NR

[1] Range and 95th percentile are determined from all samples.

[2] Below the LOD.
[3] Not Reported.

USGS National Stream Water Quality Network (NASQAN). The NASQAN program monitors water quality in the Nation's largest river basins including the Rio Grande, Colorado, Columbia and Mississippi. The program design is such that it cannot address local water quality conditions along the major rivers but it can assess regional variability. The data reported are from January 1, 1995 to September 30, 1998. The LOD for diazinon was 0.002 :g/L.

Diazinon has been detected in all of the major rivers in NASQAN. In the Rio Grande, Mississippi, Columbia, and Colorado rivers, diazinon was detected in 33%, 26%, 7%, and 7% of the samples, respectively. Concentrations ranged up to 0.207 :g/L (see Table 11 for mean, median, and 95th percentile).

Finding diazinon in these large rivers is extremely important. Since the volume of water flowing in these rivers is very large, any pesticide found in the river will be significantly diluted. Therefore, the total mass of diazinon in these rivers is very high.

Table 11. Results from the USGS NASQAN surface water monitoring program.

River Basin	Sites	Samples	Detects	Range[1]	Mean	95th Percentile	Median
Rio Grande	6	193	64	0.207 - ND[2]	0.011	0.055	ND
Mississippi	23	794	203	0.102 - ND	0.003	0.011	ND
Columbia	7	228	16	0.009 - ND	ND	0.003	ND
Colorado	9	162	12	0.008 - ND	ND	0.004	ND

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.
[2] Below the LOD.

National Survey of Pesticide in Drinking Water (NPS). The EPA's NPS was designed to determine the frequency of pesticide and nitrate-nitrogen contamination in ground water by sampling community water systems and rural drinking water wells nationwide. A total of 1,349 wells (783 rural domestic wells and 566 community water system wells) were randomly selected and sampled once for diazinon (parent only) in 38 states (USEPA, 1990). No diazinon was detected using an LOD of 1.10 :g/L.

USGS Tuolumne River Study. The USGS conducted a study in the Tuolumne River (TR) Basin in California to compare the occurrence, concentrations and mass loading of pesticides in urban and agricultural storm runoff (Kratzer, C.R., 1998). Samples were collected in February 1994-95 during significant storm events after the main pesticide application on dormant almond orchards. There were five storm drains in Modesto, California sampled during the storms, accounting for 47% of the urban area in Modesto with drainage to surface waters. Samples were collected using a width/depth integrated sampling procedure or an auto sampler. The LOD for diazinon was 0.002 μg L^{-1}.

The frequency of detection and concentration of diazinon found in the urban and agricultural storm runoff was related to application. It appears likely that the detections in urban runoff were impacted by agricultural applications (Table 12).

Table 12. Diazinon concentrations (μg L^{-1}) in agricultural and urban runoff, Tuolumne River Basin, CA.

Location	Samples	Detects	Maximum	Median	Mass Load (lbs.)	Sampling Period
Agricultural	8	8	0.920	0.190	1.90	2/6-8/94
Urban	10	10	1.10	0.800	0.18	2/13-14/95

USGS South Platte River Basin Study. A study was conducted by the USGS in the South Platte River Basin of Colorado to compare pesticide contributions from an urban and an agricultural area (Kimbrough and Litke, 1996). The agricultural area was the lower portion of the Lonetree Creek Basin which is mainly irrigated land. Cherry Creek downstream from Cherry Creek Reservoir was used as the urban land-use area. This reach of Cherry Creek flows through mainly urban land and converges with the South Platte River in downtown Denver. Samples were collected using a depth/width integrated method over the period April 1993 to April 1994. The LOD for diazinon was 0.008 μg L^{-1}. The largest concentrations of diazinon occurred from May through September and after storm events in the urban land-use area (Table 13).

Table 13. Diazinon concentrations (μg L^{-1}) in the South Platte River, CO.

Land Use	Samples	Detects	Range	Median
Urban	25	18	0.450 - ND[1]	0.033
Agricultural	25	6	0.660 - ND	< 0.008

[1] Below the LOD.

NON-AGRICULTURAL USE STUDY SUMMARIES

EPA's Permit Compliance System (PCS) Database. The PCS database stores data for the National Pollutant Discharge Elimination System (NPDES). The Clean Water Act requires that all discharges from any point source, such as a pipe or manmade ditch, into US waters must obtain a NPDES permit. This means that facilities where discharges go directly into surface waters must obtain a permit. This database is accessible via the Internet (http://www.epa.gov/enviro/html/pcs/psc_overview.html).

The PCS database contains surface water samples from 1994 through 1998. The reported LODs range from 20 µg/L to 0.01 µg/L. A search was done for facilities holding NPDES discharge permits for diazinon (raw data are presented in Appendix A). One effluent sample (638 µg/L) was not included in the statistical analysis because the concentration seemed high considering that the influent concentration associated with this effluent sample was reported as 10.0 µg/L.

Diazinon was detected in 52% of the influent samples and 40% of the effluent samples. Concentrations ranged up to 11.0 µg/L and 10.0 µg/L for the influent and effluent samples, respectively. Mean, median, and 95th percentile concentrations are shown in Table 14.

Table 14. Diazinon concentrations (µg L^{-1}) in POTW influent and effluent in the US (PCS)

Location	Samples	Detects	Range[1]	Mean	95th Percentile	Median
Influent	293	153	11.0 - ND[2]	0.580	2.00	0.200
Effluent	311	123	10.0 - ND	0.427	1.00	0.178

[1] Range is determined from all samples. Mean, median and 95th percentile are calculated using detects only.
[2] Below the LOD.

National Effluent Toxicity Assessment Center (NETAC). A nationwide survey was conducted by NETAC to determine the occurrence of diazinon in the effluent from publicly owned treatment works (POTW) (Norberg-King et al., 1989). Samples were collected at POTWs throughout the country, as either 24-hour composite samples or grab samples (raw data in Appendix B). The average LOD for diazinon was 0.081 µg/L with an average recovery of 93%. The raw data are found in Appendix B.

A total of 26 samples were taken; 65% of these contained diazinon residues ranging in concentration up to 0.936 µg/L. Table 15 gives mean, median and 95th percentile values for the detections.

Table 15. Diazinon concentrations (µg L^{-1}) in POTW effluent in the US (NETAC)

Samples	Detects	Range[1]	Mean	95th Percentile	Median
26	17	0.936 - ND[2]	0.252	0.777	0.159

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.
[2] Below the LOD.

California's Central Contra Costa Sanitary District (CCCSD). A study completed by the California Environmental Protection Agency Department of Pesticide Regulation (DPR) and the Central Contra Costa Sanitary District (CCCSD) in Martinez, California (Singhasemanon et al., 1998) focused on characterizing the diazinon and chlorpyrifos concentrations and mass load in the sewage of residential areas, commercial sites and influent to CCCSD treatment plant. Sampling at five residential areas occurred daily from July 9-15, 1996. Residential areas contribute approximately 82% of the load to the CCCSD treatment plant. Unannounced sampling at twelve commercial sites occurred from July 18 through September 8, 1996. Pet groomers, kennels, and pest control businesses were sampled. Samples were collected at the CCCSD treatment plant from June 22 through September 10 (twice weekly), July 9 - 19 (daily), August 4 - 11 (daily), and August 31 through September 7 (daily), 1996. Samples were also taken daily from the Union Sanitary District (USD) in Alameda County and the Palo Alto Regional Water Quality Control Plant (RWQCP) in Santa Clara County from August 5 - 11, 1996. Samples were collected using programmed auto samplers. The LOD for diazinon was 0.05 : g/L.

Diazinon was detected at nine of twelve commercial sites. The largest diazinon concentration of 20.0 : g/L was detected in the sewage from a kennel (Table 16).

Table 16. Diazinon concentrations (: g L^{-1}) in sewage and POTW influent, California.

Location	Samples	Detects	Range[1]	Mean	95th Percentile	Median	Mass Load (oz)
residential	35	29	4.30 - ND[2]	0.408	1.35	0.140	1.48
commercial	32	17	20.0 - ND	2.05	13.4	0.064	0.078
CCCSD	37	37	0.940 - 0.103	0.310	0.702	0.290	NR[3]
USD	7	7	0.530 - 0.091	0.239	0.476	0.180	NR
RWQCP	7	7	0.240 - 0.066	0.147	0.225	0.150	NR

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.
[2] Below the LOD.
[3] Not reported.

Castro Valley Creek Watershed, CA. A study was conducted during the 1995-96 and 1996-97 rainy seasons (October - May) in the Castro Valley Creek (CVC) watershed (Scanlin and Feng, 1997) to determine the temporal and spatial variability of diazinon in surface water and the sources of diazinon in the watershed. The study area was in west-central Alameda County and contained a mix of residential (50%), commercial (15%) and undeveloped (35%) land. Samples were collected near the mouth of Castro Valley Creek using an autosampler during storm events. Grab samples were also collected during normal flow periods. A mean concentration for each sampled event was determined using a composite sample or calculated from discrete samples. All samples were analyzed using an enzyme linked immunosorbent assay method. The LOD for diazinon was 0.030 µg L^{-1} (Table 17).

Table 17. Diazinon concentrations (µg L^{-1}) in Castro Valley Creek, Alameda County, CA.								
Location	Samples	Detects	Range[1]	Mean	95th Percentile	Median	Mass Load (oz.)	Sampling Period
CVC	19	19	0.820-0.180	0.447	0.766	0.400	22.0	12/4/95-5/17/96
CVC	23	23	0.490-0.035	0.207	0.456	0.170	NR[2]	10/4/96-5/21/97

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below theLOD were given a value one-half the LOD.

[2] Not reported.

Diazinon concentrations in CVC appeared to peak in the spring and fall and, therefore, correlated with application patterns. The largest diazinon detections occurred after extended dry periods.

The total mass discharged in the CVC was approximately 0.3% of the total mass applied in the watershed.

Subcatchments in the CVC Watershed were also monitored to determine the spatial variability in diazinon contributions in the watershed. Grab samples were collected at the discharge points of each subcatchment. Samples were collected in April and October of 1996 and February and May of 1997. The subcatchments with the largest areas of undeveloped land had the smallest concentrations (Table 18).

Table 18. Diazinon concentrations (µg L^{-1}) in Subcatchments of the Castro Valley Creek Watershed, Alameda County, CA.							
Subcatchment	Samples	Detects	Range[1]	Mean	95th Percentile	Median	Sampling Period
One	13	10	0.662 - ND[2]	0.130	0.492	0.050	4/96 - 5/97
Two	13	11	2.96 - ND	0.380	1.82	0.050	4/96 - 5/97
Three	13	11	0.343 - ND	0.102	0.266	0.069	4/96 - 5/97
Four	13	10	3.40 - ND	0.386	1.84	0.057	4/96 - 5/97
Five	1	1	0.595	NA[3]	NA	NA	4/96

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.

[2] Below the LOD.

[3] Not applicable.

Samples were collected from 45 randomly selected street gutters during a storm event on May 15, 1996 in residential areas of subcatchments two and three. Two sites with the highest concentrations in the May storm were resampled during a storm in October 1996 with similar results, indicating they may be consistent sources for high diazinon mass loading in the CVC watershed.

Residential Runoff Study in Castro Valley Creek Watershed. A residential runoff study was conducted where diazinon was applied at two residential sites in the CVC Watershed and one in Oakland, CA (14 km from CVC Watershed) in February 1997. Diazinon was applied at two-thirds of the recommended label rate for use on ants as a spray. Grab samples of runoff from roofs, patios and driveways were taken following subsequent rainfall events. Rainfall samples were collected at the Oakland site several days after application. Diazinon was found in all samples collected as long as seven weeks after application (Table 19).

Table 19. Diazinon concentrations ($\mu g\ L^{-1}$) in rainfall and runoff in residential areas of the Castro Valley Creek Watershed, Alameda County, CA.

Location/Type	Samples	Detects	Range[1]	Mean	95th Percentile	Median	Sampling Period
Street Gutters	49	45	79.0 - ND[2]	4.36	25.5	0.080	5/96 and 11/96
Roof Drains	13	13	17.0 - 0.050	2.19	9.08	0.350	3/97 - 4/97
Patios	6	6	1,200 - 1.40	368	1,120	63.0	3/97 - 4/97
Driveways	3	3	110.0 - 6.00	69.0	107	91.0	3/97 - 4/97
Rainfall	3	3	1.30 - 0.60	0.823	1.26	0.930	3/97

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.
[2] Below the LOD.

Texas Surface-water Quality Monitoring Program (POTWs). A report prepared by the Texas Center for Policy Studies (Kelly et al, 1999) compiled studies related to the quality of drinking water, surface water and ground water in Texas over the last 15 years. The Surface Water Quality Monitoring Program (SWQMP) monitored diazinon in surface water from 1983 to 1997. A total of 151 samples were collected and more than ten of them were above the LOD for diazinon. The LOD was not given. The sampling was random and did not take into account when or where a pesticide was used, rainfall patterns or other factors that could influence the fate of a pesticide in the environment. Diazinon is a problem in POTWs because it is causing them to fail toxicity tests. There are eight large municipal POTWs where this is occurring: Cibolo Creek Municipal Authority, City of Denton, City of Big Spring, City of Greenville, City of Fort Worth, City of Temple, City of Tyler and the Trinity River Authority. Diazinon is not removed during the treatment at these plants.

Florida POTWs (FL DEP). Diazion use by professional lawn care applicators (approximately 200,000 pounds) is higher in Florida than anywhere else in the US. In Florida, whole effluent testing is done for wastewater treatment facilities; i.e., bioassay testing is done to detect toxicity from a mixture of chemicals, including diazion. In addition, Florida does not have a water quality standard for diazion. Concern for diazion in effluent from these facilities occurred as early as 1988; however, within the past five years the State has recognized an increasing occurrence of diazion-related toxicity in analyses of effluent. To date, diazion has been detected in approximately 21 facilities at concentrations ranging from 0.1 to 1.57 ug/L. The State of Florida Department of Environmental Protection is now developing a cost effective strategy for analyzing diazion in wastewater facilities (Williams, 1999, personal communication).

Oklahoma POTWs (OK DEP). Four large wastewater treatment plants have consistently failed toxicity tests from 19 to 19. The Oklahoma Department of Environmental Quality (DEP) believes that spring and summer lawncare applications are the cause of the diazinon residues in the plants. Because of these failures, USEPA's Region 6 required them to conduct an educational campaign on diazinon use. The DEP now has radio ads and newsletters for the public and also sends the newsletters to Novartis. Oklahoma does not treat for diazinon in their effluent because the only effective method is extremely expensive. The DEP recommends that Novartis be required to put the diazinon toxicity information at the top of their labels and packages in large, bold print to ensure that homeowners understand diazinon's toxicity.

King County, Washington Streams (WA DNR). Urban and suburban streams were tested for diazinon residues in the spring of 1998 by the Washington Department of Natural Resources. Nine out of the 10 streams including Thornton and Longfellow creeks in Seattle; Miller Creek in Normandy Park; Little Soos Creek in Auburn; Sunset, Lewis and Valley Creeks in Bellevue; Juanita Creek in Kirkland; and Lyon Creek in Lake Forest Park contained diazinon ranging from 0.002 to 0.425 : g/L. The contamination is most likely caused by homeowners treating their lawns in the spring. Final study results will be released later in 1999 (Frahm, 1999).

AGRICULTURAL USE STUDY SUMMARIES

Ground water

Missouri. A ground-water monitoring program was conducted to determine the quality of drinking water in agricultural areas (Sievers and Fulhage, 1992). Monitoring was conducted in eight regions considered to be vulnerable to ground-water contamination by pesticides and nitrates based on aquifer material, pesticide use, and agricultural practices. Samples were collected in March, May, September and December from December 1987 to September 1989. A total of 25 wells were sampled in each region. Diazinon was applied to only 2% of the corn grown in Missouri during this time.

Using a method with an LOD of 0.30 : g/L, diazinon was detected in 5 samples at concentrations ranging up to 1.00 : g/L. Four of the five diazinon detections were in a region characterized by glaciated aquifer materials where corn, soybeans, and wheat were the dominant crops. The other detection was in an area dominated by alluvium where corn and soybeans were grown. The average depth to water for the wells where diazinon was detected was 81 feet. There were 354 lbs. a.i. of diazinon applied to corn in six of the monitored regions; diazinon was detected in two of these. Four of the diazinon detections were in December 1987 and one in March 1988 (Table 20).

Table 20. Diazinon concentrations (: g L^{-1}) in ground water in MO.

Wells	Samples	Detects	Range[1]	Mean	95th Percentile	Median
201	804	5	1.00 - ND[2]	ND	ND	ND

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.
[2] Below the LOD.

Mississippi Pesticide Hazard Assessment Project. From March 1983 to February 1984, 143 shallow (40 - 70 foot) wells were sampled in 10 counties in the Mississippi Delta as part of the Mississippi Pesticide Hazard Assessment Project (Lane, 1987). The counties were chosen because of their high pesticide use and large agricultural production. Using an LOD of 0.01 : g/L (with a recovery of 104 ± 9.23%), seven samples were found to contain diazinon at concentrations ranging up to 0.478 : g/L.

A wood preservative was the most commonly found chemical (70.6% of all detections) suggesting that ground water in these areas may be recharged by water from the Mississippi River (Table 21).

Table 21. Diazinon concentrations (: g L^{-1}) in shallow wells in the Mississippi Delta.

Wells	Samples	Detects	Range[1]	Mean	95th Percentile	Median
143	143	7	0.478 - ND[2]	0.013	ND	ND

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.
[2] Below the LOD.

Virginia. A survey of household drinking water supplies from ground-water sources was conducted in Page, Rappahannock and Warren counties during the summers of 1989 and 1990 by the Virginia Cooperative Extension Service (Ross et al, 1991; Ross et al, 1993a,b). All three counties are in rural areas where tree fruits, beef cattle, grains and poultry are the primary agricultural production. The geology of these counties is predominantly shale and limestone wirh karst topography.

Samples were collected by homeowners as close to the well as possible with one sample collected at each site. The samples were collected from sources that were considered to be high risk based on general water chemistry (nitrate, chloride, etc.) and nearness to activities that could contaminate the water supply (agriculture, etc.). Well depths averaged approximately 200 feet. Using an LOD of 0.01 µg/L, diazinon was detected in 15 wells in two of the counties. Concentrations ranged up to 0.262 µg/L. Samples were analyzed by the pesticide research laboratory at Virginia Technical University (Table 22).

Table 22. Diazinon concentrations (µg L^{-1}) in household drinking water in VA.

County	Wells	Samples	Detects	Range[1]	Mean	95th Percentile	Median
Page	60	60	6	0.103 - ND[2]	0.012	0.075	ND
Rappahannock	40	40	9	0.262 - ND	0.023	0.086	ND
Warren	26	26	0	NA[3]	NA	NA	NA

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.
[2] Below the LOD.
[3] Not applicable.

Surface Water

San Joaquin Watershed, CA (DPR). A study is being conducted in the San Joaquin watershed by the California DPR to determine the concentration in surface water of pesticides used during the dormant spray season. Two years of the study have been completed and are reported here (Ganapathy, 1999; Bennett et al., 1998). The sampling locations are located on the San Joaquin River (SJR) near Vernalis and on Orestimba Creek, a western tributary to the SJR. Background samples were collected during the week of December 2, 1996 and December 1, 1997. Dormant season sampling began on January 20, 1997 and January 7, 1998 and continued to March 7, 1997 and March 6, 1998. Samples were collected using a depth/width integrated procedure or single grab samples. Sampling was every other day at the SJR site and twice per week at the Orestimba Creek site. Samples were analyzed by the California Department of Food and Agriculture. The LOD for diazinon was 0.04 µg/L with an average recovery of 92%.

There were no detections of diazinon in the background samples. Dormant spray use of diazinon in the study area (20,573 lbs.) during the winter of 1996-97 was down 58% from the previous winter. The winter of 1996-97 was unusual because rainfall was above average in January 1997, but February was dry. The following year had above average rainfall from January through April. Because of the wet conditions, less diazinon was applied. This may have resulted in reduced concentrations in receiving water bodies. Diazinon detections were correlated with precipitation events and pesticide applications (Table 23).

Table 23. Diazinon concentrations (: g L^{-1}) in rivers in the SJR Watershed, CA, Winter 1996-97 and 1997-98.								
Location	Samples	Detects	Range[1]	Mean	95th Percentile	Median	Mass Load (lbs.)	Sampling Period
SJR	27	10	0.102 - ND[2]	0.037	0.091	ND	NR[3]	1 - 3/98
SJR	21	3	0.070 - ND	NR	NR	NR	86	1 - 3/97
Orestimba Creek	16	3	0.139 - ND	0.036	0.117	ND	NR	1 - 3/98
Orestimba Creek	16	3	0.092 - ND	NR	NR	NR	7.9	1 - 3/97

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.
[2] Below the LOD.
[3] Not reported.

USGS San Joaquin River Basin, CA (SJRB). A study was conducted by the USGS (Domagalski, 1997) in the San Joaquin River basin to determine the variability in pesticide concentrations during the irrigation season. The San Joaquin River and selected tributaries were sampled from April to August 1992. There was no rainfall during this period. Samples were collected using width and depth integrated sampling procedures which reduced or eliminated variations in concentrations within the stream channel. The LOD for diazinon was 0.002 : g/L with a recovery between 80 and 100 percent.

Diazinon was detected in almost 100% of the samples taken from the San Joaquin River basin. Concentrations ranged up to 2.00 : g/L (see Table 24 for means, median, and 95th percentile).

A major component of the study was to determine sampling frequency needed to characterize the occurrence and distribution of pesticides in surface water in a semiarid agricultural region such as the SJRB. Results indicated that sampling three times per week is more likely to detect higher concentrations than once per week as indicated by the larger variance about the median for the more frequent sampling. Sampling once per week is sufficient if only the median concentration is important.

Table 24. Diazinon concentrations (: g L^{-1}) in surface water in the SJRB, CA Summer 1992 (USGS)						
Location	Samples	Detects	Range	Mean	95th Percentile	Median
Orestimba Creek	42	38	2.00 - ND[1]	NR[2]	NR	0.052
TID #5	18	18	0.072 - 0.005	NR	NR	0.021
SJR	18	18	0.070 - 0.004	NR	NR	0.008

[1] Below the LOD.
[2] Not reported.

USGS San Joaquin River Basin, CA (1993). The influence of pesticide and hydrology related variables on the occurrence and concentration of pesticides in surface water in the San Joaquin River (SJR) Basin was explored by the USGS during 1993 (Panshin et al., 1998). Samples were collected at four locations throughout the year at different intervals depending upon the use patterns of the pesticides being monitored as well as precipitation and irrigation timing. Samples were collected using depth/width integrated procedures. The LOD for the study was 0.002 : g L^{-1} with an average recovery of 102 ± 15% (Table 25).

Diazinon was applied throughout the year and was detected during most of the year. Maximum concentrations were measured in the winter, during the rainy season when diazinon was used on dormant orchards. The sampling location on the SJR, which received flow from the three other sampling locations, was probably not a good location to obtain maximum concentrations of diazinon in the watershed. The SJR site does represent the frequency of occurrence and gives a gross indication of concentrations. Sampling at the subbasin sites is needed if maximum concentrations are to be measured.

Table 25. Diazinon concentrations (: g L^{-1}) in the San Joaquin River Basin, CA (USGS).

Location	Samples	Detects	Range	90th Percentile	Median
Orestimba Creek	48	34	3.80 - ND[1]	0.560	0.013
Salt Slough	26	23	0.28 - ND	0.160	0.030
Merced River	40	26	2.50 - ND	0.150	0.012
SJR	28	25	0.62 - ND	0.270	0.021

[1] Below the LOD.

San Joaquin River Watershed, CA (Ross). A series of studies were conducted from the spring of 1991 until the winter of 1992-93 in the San Joaquin River (SJR) watershed to determine the distribution and mass loading of insecticides (Ross et al, 1996; Ross, 1993a, 1993b). The samples were collected approximately twice per week at one site (SJR at Laird Park) and at as many as 23 Lagrangian sites over one week periods (sampled daily). The sampling at the Lagrangian sites was triggered by the occurrence of elevated concentrations at the Laird Park site on the SJR. The sampling was timed at the Lagrangian sites so that one parcel of water could be followed through the watershed. Water samples were collected using a width/depth integrated procedure or, when stream conditions were limited, grab samples were collected. The LOD for diazinon was 0.05 : g/L (Table 26).

Peak diazinon concentrations during the dormant spray seasons in 1991-92 and 1992-93 coincided with rainfall events and peak discharges. There were 76,000 and 77,000 lbs. of diazinon applied in the study area during the dormant spray seasons in 1991-92 and 1992-93, respectively. The higher measured diazinon concentrations in the SJR in 1992-93 compared to 1991-92 were a result of the termination of a six-year drought in 1992. There were greater precipitation and larger measured discharges in the SJR in 1992-93. Diazinon oxon was detected at three Lagrangian sites during the winter of 1992-93 (0.70, 0.08 and 0.21 µg L^{-1}).

Table 26. Diazinon concentrations (µg L^{-1}) in rivers in the SJR Watershed, CA, Winter 1991-92 through Winter 1992-93. (Ross)

Location	Samples	Detects	Range[1]	Mean	95th Percentile	Median	Sampling Period
SJR	15	13	1.29 - ND[2]	0.284	1.25	0.130	12/92-2/93
Lagrangian Sites	44	30	36.8 - ND	1.18	1.69	0.150	1/14-17/93 2/6-10/93
SJR	24	3	0.28 - ND	ND	0.164	ND	7/92-9/92
Lagrangian Sites	36	5	0.32 - ND	ND	0.102	ND	7/27-31/92 8/24-28/92
SJR	21	7	0.10 - ND	ND	0.090	ND	3/92-5/92
Lagrangian Sites	20	2	0.52 - ND	0.052	0.083	ND	4/14-17/92
SJR	17	10	0.35 - ND	0.080	0.182	0.070	12/91-2/92
Lagrangian Sites	36	27	2.14 - ND	0.171	0.488	0.090	1/27-31/92 2/17-19/92

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.

[2] Below the LOD.

USGS San Joaquin-Tulare Basins, CA. The water quality in the San Joaquin-Tulare Basins was monitored over the period 1992-95 by the USGS (Dubrovsky et al., 1998). Transport of diazinon in the SJR was related to timing of diazinon applications and significant precipitation events during the dormant spray season (December-March). Over the period 1991-93, 74% of the diazinon transported in the San Joaquin River occurred in January and February.

San Joaquin, Merced, Tuolumne and Stanislaus River Watersheds (Kratzer). A study was conducted during the winter of 1994 to determine the significance of east-side sources to total diazinon transport in the San Joaquin River (SJR) Basin (Kratzer, 1997). Samples were collected from three tributaries (Merced, Tuolumne and Stanislaus rivers) of the SJR and downstream from the three tributaries. Samples were also collected from two agricultural drains on the Merced River. Sampling occurred throughout two storms in January and February 1994. Dry periods preceded each storm, during which diazinon application occurred. Grab samples or depth/width integrated samples were collected depending on the river conditions. The LOD for the study was 0.002 µg L^{-1} with an average recovery of 84%. The diazinon load from each storm represented 0.05% of the total pesticide applied during the previous dry period (Table 27).

Table 27. Diazinon concentrations (µg L^{-1}) in surface water in the San Joaquin River Basin, CA. (Kratzer)

Location	Samples	Detects	Range	median	Mass Load (lbs.)	Sampling Period
Merced River drains	NS[1]	NS	NS	NS	NS	1/23-25/94
	4	4	2.3 - 0.78	1.05	NR[2]	2/6-8/94
Merced River[3]	3	3	0.61 - 0.30	NR	NR	1/23-25/94
	11	11	0.25 - 0.07	NR	1.5	2/6-8/94
Tuolumne River[3]	3	3	2.9 - 0.20	NR	NR	1/23-25/94
	11	11	0.91 - 0.06	NR	1.8	2/6-8/94
Stanislaus River[3]	3	3	0.09 - 0.01	NR	NR	1/23-25/94
	11	11	0.08 - 0.01	NR	0.1	2/6-8/94
SJR[3]	3	3	0.70 - 0.02	NR	19.6	1/23-25/94
	11	11	0.35 - 0.15	NR	7.8	2/6-8/94

[1] No sample due to insufficient flow.
[2] Not reported.
[3] Range approximated from graphs.

San Joaquin and Sacramento River Watersheds (USGS-CA). The California Regional Water Quality Control Board (RWQCB) and the USGS collaborated on a study to determine the fate of dormant spray pesticides applied in California's Central Valley and transported via surface water to the San Francisco estuary (Kuivila and Foe, 1995). Samples were collected from the Sacramento River (SR), the San Joaquin River (SJR) and two tributaries of the SJR, all of which drain into the estuary. Samples were collected daily (twice daily at Vernalis on the SJR) in January and February 1993 using a depth-integrating, discharge-weighted sampler at either one or three verticals. Diazinon, methidathion, chlorpyrifos and malathion were the focus of this study. The LOD for diazinon was 0.03 µg/L. There were field blanks every 20 samples, 10% duplicates and a recovery of greater than or equal to 83% (Table 28).

The frequency of detection and concentration of diazinon in the SR and SJR were related to the timing of storm events and pesticide applications. Diazinon was not found at high concentrations in January in the SR even though there was significant rainfall because application occurred after the major storms. There were elevated levels of diazinon in February in the SR, and in the SJR in both January and February, indicating that significant rainfall events followed pesticide application. The load of diazinon in the SR in January and February was 340 kg and was 98 kg in the SJR. The first pulse of diazinon in February was followed in the SR from Sacramento to the San Francisco estuary. The diazinon concentration at Sacramento was 0.393 : g/L; six days later and 119 km downstream it was 0.107 : g/L.

Table 28. Diazinon concentrations (: g L^{-1}) in surface water in the San Joaquin and Sacramento River Watersheds, CA, Spring 1993.[1] (USGS-CA)

Location	Samples	Detects	Range[2]	Mean	95th Percentile	Median
SR at Rio Vista	16	16	0.281 - 0.037	0.117	0.260	0.096
SJR at Vernalis	19	19	1.07 - 0.043	0.309	0.830	0.263

[1] Tabular data available only at these sites and for 2/5/93 to 2/25/93 only.
[2] Range, mean, median and 95th percentile are determined from all samples.

Sacramento River Watershed, 1997-98 (CA-DPR). The California DPR conducted a surface water monitoring study in the Sacramento River (SR) watershed to characterize the occurrence and distribution of organophosphate and carbamate insecticides, including diazinon, and soil applied herbicides that are routinely applied during the winter months (Nordmark, 1998a). Samples were collected at three locations, two on the Sutter Bypass (Karnak and Kirkville) and one on the SR (Alamar). The sampling locations were chosen so as to optimize the sampling of runoff from agricultural areas where dormant spray pesticides are used. Sampling was from January 7, 1998 through March 6, 1998. Background sampling was conducted prior to this during the week of December 1, 1997. Samples were collected using a depth-integrated sampler at two of the sites (Alamar and Karnak) and subsurface grab samples were taken at the third site (Kirkville). Samples were collected every two days on the SR and twice a week on Sutter Bypass. The LOD for diazinon was 0.04 : g/L. The average percent recovery for diazinon was 94.7% with a standard deviation of 7.4%. Sample analysis was conducted by the California Department of Food and Agriculture (Table 29).

There were no detections during the background sampling period. Diazinon was detected in every sample but one from January 30 to February 27 in the SR. The period over which the sampling occurred was an unusually high rainfall period, with almost daily measurable rains from the end of December through the end of February. This may have reduced the concentration of diazinon in samples.

Table 29. Diazinon concentrations (: g L^{-1}) in the Sacramento River Watershed, CA, Winter 1997-98 (CA-DPR).

Location	Samples	Detects	Range[1]	Mean	95th Percentile	Median
SR	27	12	0.170 - ND[2]	0.050	0.120	ND

Table 29. Diazinon concentrations (µg L^{-1}) in the Sacramento River Watershed, CA, Winter 1997-98 (CA-DPR).

Sutter Bypass	18	6	0.096 - ND	ND	0.090	ND

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.
[2] Below the LOD.

Sacramento River Watershed, 1996-97 (CA DPR, CDFA). A study conducted during the winter of 1996-97 by the California DPR and the California Department of Food and Agriculture (CDFA) (Nordmark et al, 1998b) was a precursor to the above study (Table 29). The sampling locations for Sutter Bypass were the same as in the above study but the sampling location on the SR was at the water intake for the West Sacramento Valley Water Treatment Plant at Bryte. The sampling period was somewhat abbreviated due to flooding in January. Background sampling was conducted during the week of December 2, 1996; sampling continued from January 20, 1997 until the end of the dormant spray season (March 7). During this period, sampling was every other day for the SR and twice weekly at Sutter Bypass. Sampling methodologies and analytical procedures were similar as in the above study. The LOD for diazinon was 0.04 µg/L (Table 30).

Diazinon was not detected during the background sampling period. Diazinon detections during the remaining sampling period were correlated with rainfall events at both locations. Approximate diazinon use in the area was 32% lower than in previous years because of the heavy rainfall in January. There were 52,500 lbs of diazinon applied in January and February 1997, whereas the usage during the same period in 1995 and 1996 averaged 77,000 lbs. Although rainfall was very heavy in January, there was no significant precipitation after January 29. Therefore, the concentrations and mass loading from this study are lower than for a typical dormant spray season.

Table 30. Diazinon concentrations (µg L^{-1}) in the Sacramento River Watershed, CA, Winter 1996-97 (CA-DPR, CDFA).

Location	Samples	Detects	Range[1]	Mean	95th Percentile	Median	Mass Load (lbs)
SR	21	4	0.065 - ND[2]	ND	0.064	ND	127
Sutter Bypass	14	7	0.086 - ND	ND	0.071	ND	202

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.
[2] Below the LOD.

Sacramento, Merced, Salinas and Russian River Watersheds, CA (Ganapathy). The Sacramento, Merced, Salinas, and Russian rivers were monitored for one year for organophosphate and carbamate insecticides (Ganapathy et al., 1997). The purpose of the study was to characterize the frequency and concentration of pesticides in runoff from agricultural areas in these watersheds.

Samples were collected from one site on each river weekly for one year. Samples were collected with an auto sampler on the SR which resulted in 20 L collected over a period of three days. The auto sampler was used on the Russian and Merced rivers up to January 1995 when heavy flooding occurred. The remaining samples were either depth/width integrated samples or just grab samples when the flow was too high. The samples collected on the Salinas River were either grab or depth/width integrated. Increased sampling frequency (twice/week) on the Merced River occurred from January 31 through March 6, 1994 to concur with the dormant spray season. Samples were analyzed by the California Department of Food and Agriculture. The LOD for diazinon was 0.05 : g/L with an average recovery of 95% (Table 31).

During the sampling period, 150,011; 3989; 62,000 and 2,220 lbs. of diazinon were applied upstream of the sampling sites in the Sacramento, Merced, Salinas and Russian river watersheds, respectively. Diazinon detections were associated with peak discharge during the rainy season (October - March). The frequency and concentration of diazinon may have been diminished by the three-day sampling composite method as by well as flood events.

Table 31. Diazinon concentrations (: g L^{-1}) in rivers in the Sacramento, Merced, Salinas and Russian River Watersheds, CA, 1993-95 (Ganapathy)

Location	Samples	Detects	Range[1]	Mean	95th Percentile	Median	Sampling Period
SR	52	2	0.11 - ND[2]	ND	ND	ND	11/93 - 11/94
Merced River	57	3	0.17 - ND	ND	ND	ND	6/94 - 6/95
Salinas River	52	0	NA[3]	NA	NA	NA	8/94 - 8/95
Russian River	52	1	0.076 - ND	NA	NA	NA	8/94 - 8/95

[1] Range, mean, median and 95th percentile are determined from all samples. Samples below the LOD were given a value one-half the LOD.

[2] Below the LOD.

[3] Not applicable.

<u>Pilot Reservoir Monitoring Study.</u> In order to gain additional information on the occurrence of pesticides at vulnerable water supplies, the Office of Pesticide Programs has initiated a pilot reservoir monitoring study jointly with the NAWQA program of the United States Geological Survey. This study is collecting samples at 12 reservoirs used for drinking water supplies that were chosen to represent a variety of sites that are vulnerable to pesticide contamination from across the United States. Samples were taken at the intake of the drinking water facility and a paired finished water sample was taken at the same time. In addition, some sites had a sample taken at the release from the reservoir when that point was not closely associated with the intake. Samples were taken on at least 12 and up to 22 dates during 1999 and the winter of 2000.

Preliminary results (Blomquist, 2000) indicate that diazinon was found at 10 of the 12 reservoirs monitored (detection frequencies of 7 - 96%). Of the 245 samples collected at drinking water intakes, diazinon was detected in 84 up to a concentration of 0.11 $\mu g\ L^{-1}$. Diazinon was not found in any of 171 finished water samples at those same facilities; however, the samples were not analyzed for either of the two major diazinon degradates: diazoxon, or oxypyrimidine. There is evidence that diazoxon is formed during drinking water treatment as discussed below. It is worth emphasizing that although these are preliminary results, they have passed through all USGS QA/QC procedures. Additional monitoring is continuing through 2000.

Drinking Water Treatment. The Office of Pesticide Programs has completed a review of the effects of drinking water treatment on pesticides in water (Hetrick *et al.,* 2000). This review indicates that standard drinking water treatment, consisting of flocculation/sedimentation and filtration does not substantially affect concentrations of pesticides in drinking water. However, some studies (Aizawa and Magara, 1992; Magara *et al.,* 1992; Ohashi *et al.* 1994) indicate that disinfection with chlorine or ozone converts diazinon to diazoxon. Further, diazoxon is stable in the presence of chlorine for at least 48 hours (Magara *et al,* 1992). Disinfection is performed at greater than 92% of surface water based facilities at any size range. Chlorination is most commonly used disinfectin method. In addition, Domagalski, 1996, has found diazoxon present in ambient surface water in California at concentrations about 2.5% of the parent on average. This is of substantial concern as there is some evidence that diazoxon is 1000 times as toxic as parent diazinon.

AIR, RAIN AND FOG

Diazinon is one of the most common organophosphate compound detected in air, rain, and fog (followed by methyl parathion, parathion, malathion, chlorpyrifos, and methidathion). In the 1970's, diazinon was detected throughout the US. Since then, most sampling and analyses have been done in California fog and air.

Air**.** In 1971, diazinon was detected in approximately 80% of the sites sampled nationally. Over 60% of these sites also contained diazoxon. By 1988, sampling was done only in California. Diazinon and diazoxon were detected in approximately 90% and 85% of the sites sampled. A 1976 study indicated that there was a strong correlation between high air concentrations, regional use, and cropping patterns. The primary use of diazinon at that time was in the Corn Belt and Appalachian regions where diazinon was used on corn and tobacco. High diazinon concentrations were also observed in areas where its reported agricultural use was low, possibly indicating the influence of home and garden uses. Concentrations of diazinon in air range from 0.0011 to 306.5 ng/cubic meter; for diazoxon they range from 0.0014 to 10.8 ng/cubic meter.

Recent USGS monitoring also indicates that diazinon is being found in Sacramento urban air samples as well as samples taken in agricultural areas upwind and downwind of the urban site. Pesticides can become airborne though volatilization and wind erosion both during and after application. The USGS conducted a study to monitor the occurrence, concentration, and geographical distribution of agricultural pesticides in air over the Mississippi River. The study was conducted from New Orleans, Louisiana to St. Paul, Minnesota during the first 10 days of June 1994. Rainfall was frequent during this period and winds were variable. Herbicides are the most common pesticides used in this area. Each sample was analyzed for 42 pesticides (including 18 insecticides) and 3 degradates; seven insecticides, 16 herbicides, and two degradates were detected. Diazinon was detected in all of the samples (100%) at concentrations ranging from 0.04 to 0.36 ng/m^3. Chlorpyrifos, fonofos, malathion, metolachlor, and metribuzin were also detected in 100% of the samples. The highest concentrations of diazinon, chlorpyrifos, and malathion were observed near major metropolitan areas where agricultural use of these chemicals was minimal.

Recent USGS monitoring indicates that diazinon is being found in Sacramento urban air samples as well as samples taken in agricultural areas upwind and downwind of the urban site (Majewski, 1999, personal communication).

<u>Rain</u>**.** Concentrations of diazinon in rain ranged from 1.3 to 2,000 ng L^{-1}; for diazoxon they ranged from 1.3 to 115.8 ng/L (Majewski and Capel, 1995). More recent monitoring (April-September 1995) has been conducted by the USGS in the Mississippi River valley. Samples were analyzed for 26 herbicides, 18 insecticides, and 3 degradation products in three agricultural/urban regions. Five insecticides, including diazinon, were frequently detected. In two of the three urban sites, significantly more diazinon was detected in the rainfall than at the agricultural sites.

<u>Fog</u>**.** Of the 48 pesticides that have been detected in fog, only diazinon was near or exceeded the human health limits for drinking water in 5 of 24 fog events (Majewski and Capel, 1995). Concentrations of diazinon in fog were measured as high as 76,300 ng L^{-1} ; for diazoxon they range up to 28,000 ng L^{-1}.

MODELING

<u>Ground Water</u>

The annual application rate used for diazinon (9.8 lbs. a.i. acre^{-1}) is the maximum recommended value for corn. Table 29 shows the input parameter values used in SCI-GROW (Screening Concentrations in Ground Water) (Barrett, 1997) for diazinon. The K_{oc} value (561 L kg^{-1}) was the average value for all the soil types. This value was chosen because there was a less than a three-fold variation in the K_{oc}

values for the soils, indicating that adsorption is correlated with the organic carbon content of the soil. The aerobic soil metabolic half-life (38 days) was the average of two values. The groundwater concentration resulting from the SCI-GROW modeling is shown in Table 32a. Since there is relatively little temporal variation in ground water compared to surface water, the concentrations can be considered as acute and chronic values.

Table 32a. Input parameters for diazinon used in the SCI-GROW model and result.	
K_{oc} (L kg^{-1})	561
Annual Application Rate (lbs. a.i. acre^{-1})	9.8
Number of Applications	1
Aerobic Soil Metabolism half-life (days)	38
Groundwater Concentration (µg L^{-1})	0.804

Surface Water

Two sets of surface water simulations have been done for diazinon in surface water, the first supports drinking water assessment, and the second supports aquatic ecological exposure assessment. The same models, PRZM for the agricultural field, and EXAMS for the water body were used for both sets of values However, the modeling done for drinking water assessment was done using the index reservoir watershed scenario and that for ecological risk assessment was done with the standard pond scenario. The drinking water modeling is summarized below. A detailed description of the assessment is Appendix C. The description of the modeling for ecological risk assessment follow the drinking water summary.

Table 1A. Tier 2 upper tenth percentile EEC's for drinking water from diazinon applied to walnuts.

Product	Maximum	Annual Mean	Overall Mean
Maximum Label Rate			
citrus*	540 µg·L^{-1}	58.9 µg·L^{-1}	30.1 µg·L^{-1}
peaches	70.1 µg·L^{-1}	9.4 µg·L^{-1}	6.9 µg·L^{-1}
walnuts	41.5 µg·L^{-1}	10.4 µg·L^{-1}	9.7 µg·L^{-1}
Typical Use			
citrus*	85.0 µg·L^{-1}	10.6 µg·L^{-1}	4.1 µg·L^{-1}
peaches	40.5 µg·L^{-1}	5.4 µg·L^{-1}	3.0 µg·L^{-1}
walnuts	25.7 µg·L^{-1}	4.8 µg·L^{-1}	4.0 µg·L^{-1}

*Oranges in Florida were used to represent the citrus use.

Drinking Water Modeling

Modeling to support the assessment of drinking water in the human health risk assessment was done for three scenario, peaches, citrus and walnuts. The recommended values in Table 1 are from the simulation for peaches. The citrus use pattern, while legally permitted on the label, is so far removed from the typical pattern, that it was deemed inappropriate for risk assessment. It has been included here for completeness. These values were generated using the index reservoir scenario which represents the real reservoir in Illinois which is known to vulnerable to pesticide contamination. This reservoir geometry has been combined with local weather and soils to represent drinking water at vulnerable site associated with different crops. The values generated by the models were multiplied by default percent crop area factor (PCA) which accounts for the fact that is unlikely for any basin to be completely planted to agricultural crops. The use of the index reservoir and PCA are described in *Drinking Water Exposure Assessment, Parts A and B.* (U. S Environmental Protection Agency, 2000) The EEC's for the three scenarios simulated are in Table 1A. A complete description of how these values were estimated is in Appendix D.

Surface Water Modeling for Aquatic Ecological Risk Assessment

Estimated environmental concentrations (EEC's) of diazinon in surface water as a result of the highest label application rate on seven crop types (berries, tubers/bulbs, nuts, stone fruits, pome fruits, vegetables and other) were calculated using the Pesticide Root Zone Model version 3.1 (PRZM) (Carsel et al, 1997) and EXAMS 2.97.5 (Exposure Analysis Modeling System) (Burns, 1997). PRZM is used to simulate pesticide transport as a result of runoff and erosion from an agricultural field and EXAMS estimates environmental fate and transport of pesticides in surface water. The weather and agricultural practices are simulated over multiple years (25 or 36) so that the 10-year exceedence probability at the site can be estimated. The crops were chosen based on the uses for which the greatest amount of diazinon was applied according to data from Doanes Marketing Research over the period 1992-1997. PRZM is used to simulate pesticide transport as a result of runoff and erosion from an agricultural field and EXAMS estimates environmental fate and transport of pesticides in surface water. The weather and agricultural practices are simulated over multiple years (25 or 36) so that the ten year excedence probability at the site can be estimated. A partial list of input parameters for the PRZM/EXAMS modeling are given in Tables 32b and 32c.

Table 32b. PRZM/EXAMS input parameters used for all crops.

Aqueous Solubility (mg L^{-1})	40
Hydrolysis half-life (days) pH 5 pH 7 pH 9	 12 138 77
Aqueous Photolysis half-life (days)	no data
Aerobic Soil Metabolism half-life (days)	38
Aerobic Aquatic Metabolism half-life (days)	no data
Source	EFED DERs

Table 32c. PRZM/EXAMS input parameters for specific crops.					
Location/Crop	Major Land Resource Area	Soil Type/Hydrologic Soil Group	Soil/Water Partition Coefficient (K_d) (L kg^{-1})	Annual Application Rate (lbs. a.i. $acre^{-1}$)	Application Method
CA Almonds	17	Kimberlina sandy Loam/B	4.0	1 @ 3.00	Aerial Spray
CA Walnuts	17	Kimberlina Sandy Loam/B	4.0	3 @ 3.00	Aerial Spray
FL Citrus	156A	Adamsville Sand/C	3.7	2 @ 10.0	Aerial Spray
FL Cucumbers	156B	Riviera Sand/C	3.7	1 @ 4.00	Broadcast
FL Strawberries	154	Myakka Fine Sand/B	3.7	4 @ 1.0	Aerial Spray
GA Sweet Corn	133A	Lynchberg Loamy Sand/C	5.0	5 @ 1.25	Aerial Spray
GA Peaches	133A	Boswell Sandy Loam/D	8.0	3 @ 2.0	Aerial Spray
HI Pineapple[1]	NA[2]	NA	K_{oc}=434	1 @ 4.00	Aerial Spray
LA Sugarcane	131	Sharkey Clay/D	23.4	1 @ 4.00	Aerial Spray
ME Potatoes	143	Conant Silt Loam/D	23.4	1 @ 4.00	Broadcast
MI Blueberries	97	Rimer Loamy Sand/C	5.0	5 @ 1.00	Aerial Spray
MS Cotton	134	Loring Silt Loam/C	23.4	3 @ 1.00	Aerial Spray
MS Soybeans	134	Loring Silt Loam/C	23.4	1 @ 4.00	Aerial Spray
NC Tobacco	133A	Norfolk Loamy Sand/B	5.0	1 @ 3.00	Aerial Spray
NY Apples	144B	Cabot Silt Loam/D	23.4	3 @ 2.0	Aerial Spray
NY Grapes	100	Hornell Silt Loam/D	11.7	5 @ 1.0	Aerial Spray
OR Alfalfa	23	Fury Silt Loam/C	23.4	3 @ 1.5	Aerial Spray
OH Corn	111	Cardington Silt Loam/C	23.4	1 @ 9.80	Aerial Spray
TX Sorghum	77	Pullman Clay Loam/D	23.4	1 @ 4.00	Broadcast
				4 @ 0.50	Aerial Spray

[1] Modeled using GENEEC.
[2] Not applicable.

The standard EXAMS scenario used by EFED simulates a ten-hectare field draining into a one-hectare static pond, that is two meters deep and has no outlet. It is assumed that evaporation losses and inflow from rainfall and runoff are balanced. The aerial spray application method was modeled assuming an application efficiency of 95 percent with five percent spray drift. The modeling results are shown in Table 32d.

Table 32d. Upper tenth percentile (μg L^{-1}) from PRZM/EXAMS modeling.						
Location/Crop	PEAK (ACUTE)	4 DAY	21 DAY	60 DAY	90 DAY	YEARLY AVERAGE (CHRONIC)
CA Almonds	8.89	8.33	7.94	6.39	5.74	1.61
CA Walnuts	21.5	20.7	18.3	16.2	14.5	5.76
FL Citrus	386	365	312	209	160	48.8
FL Cucumbers	429	414	356	258	205	58.7
FL Strawberries	112	109	98.8	83.0	74.8	25.0
GA Sweet Corn	71.1	68.1	57.3	39.0	33.8	11.6
GA Peaches	41.5	40.1	35.2	27.1	22.3	6.61
HI Pineapples	91.2	89.4	80.5	67.2	NA[2]	NA
LA Sugarcane	73.4	70.9	62.9	53.1	50.5	13.2
ME Potatoes	72.7	68.7	58.9	45.7	37.0	11.6
MI Blueberries	37.7	36.2	32.8	22.4	19.0	6.47
MS Cotton	40.3	38.1	33.8	26.9	23.1	8.21
MS Soybeans	38.8	37.1	31.2	24.5	20.2	7.15
NC Tobacco	47.0	45.2	38.9	31.7	25.4	7.05
NY Apples	25.1	23.8	20.5	15.4	12.8	4.60
NY Grapes	10.7	10.2	9.10	7.97	7.37	3.33
OH Corn	64.9	62.8	55.2	40.9	34.6	11.2
OR Alfalfa	11.8	11.3	9.78	7.46	6.03	1.81
TX Sorghum	28.8	27.6	23.5	18.8	15.6	5.39

[1] Modeled using GENEEC.
[2] Not applicable.

There are several factors which may limit the accuracy and precision of the PRZM/EXAMS modeling. These include the selection of the typical exposure scenarios, the quality of the input data, the ability of the models to represent the real world and the number of years that were modeled. The scenarios that are selected for use in Tier II EEC calculations are the ones that are likely to produce large concentrations in the aquatic environment. Each scenario should represent a real site to which the pesticide of concern is likely to be applied. The EEC's in this analysis are accurate only to the extent that the site represents the hypothetical high exposure site. The most limiting part of the site selection is the use of the standard pond with no outlet. A standard pond is used because it provides a basis for comparing pesticides in different regions of the country on equal terms. The models also have limitations in their ability to represent some processes. The greatest limitation is the handling of spray drift. A second major limitation is the lack of validation at the field level for pesticide runoff.

EXPOSURE TO NONTARGET TERRESTRIAL ANIMALS

EFED will be using Hoerger and Kenaga estimates (1973) as modified by Fletcher and other researchers (1994) to approximate the residues on plants and insects. Hoerger-Kenaga categories represent preferred foods of various terrestrial vertebrates: fruits and bud and shoot tips of leafy crops are preferred by upland game birds; leaves and stems of leafy crops are consumed by hares and hoofed mammals; seeds, seed pods and grasses are consumed by rodents; and insects are consumed by various birds, mammals, reptiles and terrestrial-phase amphibians. Terrestrial vertebrates also may be exposed to pesticides applied to soil by ingesting pesticide granules and/or pesticide-laden soil when foraging. Rich in minerals, soil comprises 5 to 30% of dietary intake by many wildlife species (Beyer and Conner).

Hoerger-Kenaga pesticide environmental concentration estimates were based on residue data correlated from more than 20 pesticides on more than 60 crops. Representative of many geographic regions (7 states) and a wide array of cultural practices, Hoerger-Kenaga estimates also considered differences in vegetative yield, surface/mass ratio and interception factors. In 1994, Fletcher, Nellessen and Pfleeger reexamined the Hoerger-Kenaga simple linear model ($y=B^1x$, where x=application rate and y=pesticide residue in ppm) to determine whether the terrestrial EEC's were accurate. They compiled a data set of pesticide day-0 and residue-decay data involving 121 pesticides (85 insecticides, 27 herbicides, and 9 fungicides from 17 different chemical classes) on 118 species of plants. After analyses, their conclusions were that Hoerger-Kenaga estimates needed only minor modifications to elevate the predictive values for forage and fruit categories from 58 to 135 ppm and from 7 to 15 ppm, respectively. Otherwise, the Hoerger-Kenaga estimates were accurate in predicting the maximum residue values after a 1 lb ai/acre application. Mean values represent the arithmetic mean of values from samples collected the day of pesticide treatment. These values, in the table below, are the predicted 0-day maximum and mean residues of a pesticide that may be expected to occur on selected avian, mammalian, reptilian or terrestrial-phase amphibian food items immediately following a direct single application at a 1 lb ai/acre application rate. For pesticides applied as a nongranular product (*e.g.*, liquid, dust), the estimated environmental concentrations (EECs) on food items following product application are compared to LC50 values to assess risk.

Table 33: Estimated Environmental Concentrations on Avian and Mammalian Food Items (ppm) Following a Single Application at 1 lb ai/A)

Food Items	EEC (ppm) Predicted Maximum Residue[1]	EEC (ppm) Predicted Mean Residue[1]
Short grass	240	85
Tall grass	110	36
Broadleaf/forage plants and small insects	135	45
Fruits, pods, seeds, and large insects	15	7

[1] Predicted maximum and mean residues are for a 1 lb ai/a application rate and are based on Hoerger and Kenaga (1972) as modified by Fletcher *et al.* (1994).

The Fate Model was used to calculate maximum initial EECs on terrestrial food items for multiple applications by integrating the foliar or dissipation rate with the number and frequency of applications. The use of maximum residues may overestimate diazinon residues in the case of multiple applications, because with each additional application, the additivity of maximum residues becomes progressively less probable. While the Fate Model is useful, the selection of maximum or mean residue levels currently remains unresolved for multiple applications, in general. While maximum residues were used to assess risks, it is clear that diazinon applications pose acute risks to sensitive bird and small mammal species following only one application. Additional applications simply increase the probability of more adverse effects on wildlife for a longer exposure period.

A foliar dissipation half-life of 5.3 days was used to calculate residues in the Fate Model (Willis and McDowell, 1987). Diazinon may volatilize, photodegrade and wash-off leaf surfaces as well as degrade by microbial metabolism.

EXPOSURE TO NONTARGET FRESHWATER AQUATIC ANIMALS

EFED uses models to estimate exposure to freshwater aquatic animals since the monitoring data presented in the water resources section was generally not from targeted diazinon studies and therefore, peak concentrations could not be estimated.

GENEEC provides an upper bound on the concentration of pesticide that could be found in drinking water and therefore can be appropriately used in screening calculations. If a risk assessment performed using GENEEC output does not exceed the level of concern, then one can be reasonably confident that the risk will also be below the level of concern. However, since GENEEC can substantially overestimate true drinking water concentrations, it will be necessary to refine the GENEEC estimate if the level of concern is exceeded. The EEC'S do not reflect the concentration of any diazinon degradates.

As a Tier I assessment, EFED uses GENEEC (EPA, 1995) which is a screening model designed to estimate surface-water concentrations to use in ecological risk assessments. As such, it provides upper-bound concentrations that might be found in ecologically sensitive environments because of the use of a pesticide. GENEEC is a single runoff event model that can account for spray drift from multiple applications. GENEEC is "hardwired" to represent a 10-hectare field immediately adjacent to a 1-hectare pond that is two meters deep with no outlet. The pond receives a spray drift event from each application plus one runoff event. The runoff event moves a maximum of 10 percent of the applied pesticide into the pond. The GENEEC program uses basic environmental fate data and pesticide label information to estimate the EECs. The runoff event occurs two days after the last application. The model takes into account adsorption to the soil or sediment, incorporation of the pesticide, degradation in soil before runoff, and degradation within the water body. The model also accounts for direct deposition of off-target spray drift onto the water body (assuming 5% of the application rate for aerial applications and 1% for ground applications).

It was anticipated that Risk Quotients (RQs) calculated using the GENEEC EECs would exceed the LOCs for diazinon. When LOC's are exceeded by GENEEC estimates, a second level of screening using the Pesticide Root Zone Model version 3.1.2 (PRZM) (Carsel et al., 1997) and EXAMS 2.97.5 (Exposure Analysis Modeling System) (Burns, 1997) is used. The aquatic EECs (Tier II assessment) for diazinon, with the exception of the modeling scenarios used for pineapple and lawns, are estimated using PRZM/EXAMS. The GENEEC model was used for pineapple and lawns because EFED currently does not have a PRZM/EXAMS modeling scenario for these use sites.

The PRZM/EXAM modeling tools used by EFED are designed to be conservative tools; 90% of simulated sites are expected to have environmental concentrations which are lower than the Tier II estimates. EFED uses environmental fate and transport computer models to calculate refined EECs. PRZM simulates pesticide surface water runoff on daily time steps, incorporating runoff, infiltration, erosion, and evaporation. The model calculates foliar dissipation and runoff, pesticide uptake by plants, soil microbial transformation, volatilization, and soil dispersion and retardation. EXAMS simulates pesticide fate and transport in an aquatic environment (one hectare body of water, two meters deep with no outflow). The EECs have been calculated so that in any given year, there is a 10% probability that the maximum average concentration of that duration in that year will equal or exceed the EEC at the site. The Tier II model uses a single site which represents a high exposure scenario for the use of the pesticide on a particular crop use site. The weather and agricultural practice are simulated at the site over multiple years so that the probability of an EEC occurring at that site can be estimated. Sites were chosen for refined EEC's because they are major crops grown in areas where both freshwater and estuarine/marine organisms may be exposed to a pesticide through spray drift or runoff or a combination of both.

Acute risk assessments are performed using peak EEC values for single and multiple applications. Chronic risk assessments are performed using the 21-day EECs for invertebrates and 60-

day EECs (56-day EECs for pineapple and lawns due to the use of the GENEEC model) for fish. The modeling results are shown in Table 32d.

ECOLOGICAL EFFECTS CHARACTERIZATION

Organophosphate toxicity is based on the inhibition of the enzyme acetylcholinesterase which cleaves the transmitter acetylcholine, thereby interfering with proper neurotransmission in cholinergic synapses and neuromuscular junctions. While mild cholinesterase inhibition is primarily reversible for humans, for wildlife even slight cholinesterase inhibition can make animals more susceptible to predation and accidents often resulting in animal death.

1. Ecological Toxicity Data

Available data indicate diazinon is very highly toxic to birds, mammals, beneficial insects, and freshwater, estuarine and marine animals. In addition to adverse effects resulting from exposure to parent diazinon, terrestrial vertebrates may be exposed to the environmental degradates, diazoxon and oxypyrimidine. The toxicity of these degradates to terrestrial vertebrates is unknown, although submitted human health effect data implies that diazoxon may be more toxic than parent diazinon.

Below is a presentation of the EPA's current diazinon ecological toxicity data base:

a. Toxicity to Terrestrial Animals

i. Birds, Acute and Subacute

An acute oral toxicity study using the technical grade of the active ingredient (TGAI) is required to establish the toxicity of diazinon to birds. The avian oral LD_{50} is an acute, single-dose laboratory study designed to estimate the quantity of toxicant required to cause 50% mortality in a test population of birds. The preferred test species is either the Mallard Duck, a waterfowl, or Bobwhite quail, an upland gamebird. The TGAI is administered by oral intubation to adult birds, and the results are expressed as LD_{50} milligrams (mg) active ingredient (a.i.) per kilogram (kg). The toxicity value (LD_{50}) appearing in the shaded area of the table will be used to calculate the acute avian risk quotients (RQ's) in subsequent sections. Toxicity category descriptions are the following:

If the LD_{50} is *less than 10 mg a.i./kg*, then the test substance is *very highly toxic*.
If the LD_{50} is *10-to-50 mg a.i./kg*, then the test substance is *highly toxic*.
If the LD_{50} is *51-to-500 mg a.i./kg*, then the test substance is *moderately toxic.*
If the LD_{50} is *501-to-2,000 mg a.i./kg*, then the test substance is *slightly toxic.*
If the LD_{50} is *greater than 2,000 mg a.i./kg*, then the test substance is *practically nontoxic.*

Table 34: Avian (also Reptilian and Terrestrial-Phase Amphibian) Acute Oral Toxicity - Technical

Species	% ai	LD_{50} (mg a.i./kg)	Toxicity Category	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Brown-headed Cowbird *(Molothrus ater)*	88.2	LD_{50}= 69.0 NOAEL=<10.0	moderately toxic	40895303/Fletcher, D. & C.Pedersen/1988	Supplemental
Canada Goose (*Branta canadensis)*	86.6	LD_{50}= >6.0 & <39.3[a,b]	very highly toxic	FEODIA07/Grimes, J. & M. Jaber/1987e[c]	Supplemental
Canada Goose (*Branta canadensis)*	86.6	6.16 (C.L. 2.89-11.52)[2]	very highly toxic	FEODIA08/D.W. Fletcher/1987a[c]	Supplemental
House Sparrow *(Passer domesticus)*	>90.0	7.5	very highly toxic	0020560/Schafer, E. W. & R. B. Brunton/1979[c]	Supplemental
Mallard Duck *(Anas platyrhynchos)*	97	6.38 (C.L. 4.90-8.50)[2]	very highly toxic	FEODIA06/D.W. Fletcher/1987c[c]	Core
Mallard Duck *(Anas platyrhynchos)*	86.6	6.66	very highly toxic	FEODIA04/D.W. Fletcher/1987b[c]	Core
Mallard Duck *(Anas platyrhynchos)*	89.0	3.54	very highly toxic	0160000/Hudson, R., et.al/1984	Core
Mallard Duck (Anas platyrhynchos)	88.2	LD_{50}= 1.44 NOAEL=0.316	very highly toxic	40895301/Fletcher, D. & C.Pedersen/1988	Core
Mallard Duck *(Anas platyrhynchos)*	86.6	LD_{50}=14 NOAEL= <6.0	highly toxic	not given/Grimes, J. & M. Jaber/1987	Supplemental
Mallard Duck *(Anas platyrhynchos)*	89.2	LD_{50}= 8.7	very highly toxic	FEODIA02/CIBA-GEIGY/1981	Supplemental
Mallard Duck *(Anas platyrhynchos)*	86.6	<3.16[a]	very highly toxic	FEODIA03/Bio-Life/1987[c]	Supplemental
Mallard Duck *(Anas platyrhynchos)*	97.0	<3.16[a]	very highly toxic	FEODIA05/Bio-Life/1987[c]	Supplemental
Mallard Duck *(Anas platyrhynchos)*	86.6	>6 & <24.6[a]	very highly toxic	FEODIA01/Wild Life Int./1987[c]	Supplemental
Northern Bobwhite Quail *(Colinus virginianus)*	99.0	10	highly toxic	RO0DI002/Hill, E. & M. Camardese/1984	Supplemental
Northern Bobwhite Quail *(Colinus virginianus)*	89.0	LD_{50}= 5.2 (C.L. 3.5-7.6)	very highly toxic	00109015/Fink, R./1976	Supplemental
Red-winged Blackbird *(Agelaius phoeniceus)*	>90.0	3.2[b]	very highly toxic	0020560/Schafer/1972	Supplemental
Ring-necked Pheasant *(Phasianus colchicus)*	89.0	4.33	very highly toxic	0160000/Hudson, R., et.al/1984	Supplemental

Table 34: Avian (also Reptilian and Terrestrial-Phase Amphibian) Acute Oral Toxicity - Technical

Species	% ai	LD_{50} (mg a.i./kg)	Toxicity Category	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Brown-headed Cowbird *(Molothrus ater)*	88.2	LD_{50}= 69.0 NOAEL=<10.0	moderately toxic	40895303/Fletcher, D. & C.Pedersen/1988	Supplemental
Canada Goose (*Branta canadensis)*	86.6	LD_{50}= >6.0 & <39.3[a,b]	very highly toxic	FEODIA07/Grimes, J. & M. Jaber/1987e[c]	Supplemental
Canada Goose (*Branta canadensis)*	86.6	6.16 (C.L. 2.89-11.52)[2]	very highly toxic	FEODIA08/D.W. Fletcher/1987a[c]	Supplemental
House Sparrow *(Passer domesticus)*	>90.0	7.5	very highly toxic	0020560/Schafer, E. W. & R. B. Brunton/1979[c]	Supplemental
Mallard Duck *(Anas platyrhynchos)*	97	6.38 (C.L. 4.90-8.50)[2]	very highly toxic	FEODIA06/D.W. Fletcher/1987c[c]	Core
Mallard Duck *(Anas platyrhynchos)*	86.6	6.66	very highly toxic	FEODIA04/D.W. Fletcher/1987b[c]	Core
Mallard Duck *(Anas platyrhynchos)*	89.0	3.54	very highly toxic	0160000/Hudson, R., et.al/1984	Core
Mallard Duck (Anas platyrhynchos)	88.2	LD_{50}= 1.44 NOAEL=0.316	very highly toxic	40895301/Fletcher, D. & C.Pedersen/1988	Core
Mallard Duck *(Anas platyrhynchos)*	86.6	LD_{50}=14 NOAEL= <6.0	highly toxic	not given/Grimes, J. & M. Jaber/1987	Supplemental
Mallard Duck *(Anas platyrhynchos)*	89.2	LD_{50}= 8.7	very highly toxic	FEODIA02/CIBA-GEIGY/1981	Supplemental
Mallard Duck *(Anas platyrhynchos)*	86.6	<3.16[a]	very highly toxic	FEODIA03/Bio-Life/1987[c]	Supplemental
Mallard Duck *(Anas platyrhynchos)*	97.0	<3.16[a]	very highly toxic	FEODIA05/Bio-Life/1987[c]	Supplemental
Mallard Duck *(Anas platyrhynchos)*	86.6	>6 & <24.6[a]	very highly toxic	FEODIA01/Wild Life Int./1987[c]	Supplemental
Northern Bobwhite Quail *(Colinus virginianus)*	99.0	10	highly toxic	RO0DI002/Hill, E. & M. Camardese/1984	Supplemental
Northern Bobwhite Quail *(Colinus virginianus)*	89.0	LD_{50}= 5.2 (C.L. 3.5-7.6)	very highly toxic	00109015/Fink, R./1976	Supplemental
Male Bullfrog (*Rana catesbiana)*	89.0	>2,000	practically nontoxic	0160000/Hudson, R., et.al/1984	Supplemental

[1] Core means study satisfies guideline. Supplemental means study is scientifically sound, but does not satisfy guideline.
[a] LD50 value reported when regurgitation was considered. When regurgitation was not considered, the LD50 value was 25 mg ai/kg with 95% confidence limits of 18-45 mg ai/kg for geese, and 14 mg ai/kg with 95% confidence limits of 11-18 mg ai/kg for mallards.
[b] Adjusted for percent active ingredient (ai).

[c] Reviews by L. Turner of EPA for 1987 Diazinon hearing FIFRA Docket Nos. 562, et al.
[2] C.L. is the 95% confidence limits, the upper and lower boundaries, of which one is 95 percent confident that the statistically derived $LD_{50,}$ is between these values.

Table 35: Avian Acute Oral Toxicity - End Use Formulations

Species/Formulation	% ai	LD_{50} (mg a.i./kg)	Toxicity Category	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Brown-headed Cowbirds *(Molothrus ater)*/Emulsifiable Concentrate	48.1	LD_{50}= 46.4 NOAEL=<10	highly toxic	40895309/Fletcher, D. & C. Pedersen/1988	Supplemental
Brown-headed Cowbird *(Molothrus ater)*/Granular	14.7	LD_{50}= 6.85 NOAEL=<2.15	very highly toxic	40895306//Fletcher, D. & C.Pedersen/1988	Supplemental
House Sparrow *(Passer domesticus)*/Granular	14.3	2.5	very highly toxic	RO0DI001/BalcombR., et.al./1984	Supplemental
Mallard Duck *(Anas platyrhynchos)*/Granular	14.7	LD_{50}= 2.34 NOAEL=0.681	very highly toxic	40895305/Fletcher, D. & C. Pedersen/1988	Core
Mallard Duck *(Anas platyrhynchos)*/ Emulsifiable Concentrate	48.1	LD_{50}= 1.18 NOAEL=.316	very highly toxic	40895307/Fletcher, D. & C. Pedersen/1988	Core
Northern Bobwhite Quail *(Colinus virginianus)*/ Granular	14.3	8 (C.L. 6-11)	very highly toxic	RO0DI002/Hill, E. & M.. Camardese/1984	Supplemental
Northern Bobwhite Quail *(Colinus virginianus)*/ Microencapsulated	23.0	LD_{50}= 472 LD_{50}(a.i.)=108.5 NOAEL=<251	moderately toxic	AC240993/Beavers, J./1978a	Supplemental
Red-winged Blackbird *(Agelaius phoeniceus*)/Granular	14.3	1.8	very highly toxic	RO0DI001/Balcomb, R., et.al./1984	Supplemental

[1] Core means study satisfies guideline. Supplemental means study is scientifically sound, but does not satisfy guideline.
[2] C.L. is the 95% confidence limits, the upper and lower boundaries, of which one is 95 percent confident that the statistically derived $LD_{50,}$ is between these values.

In the above table the percent active ingredient has been adjusted for comparability, but in some instances, it appears that the end-use formulation enhanced the toxicity of technical diazinon. A 1986 EFED memorandum (H. Craven to G. LaRocca, 7/27/86) indicates that sulfotepp, a manufacturing process contaminant, was most likely the causative agent. Because sulfotepp is very highly toxic to mammals (rat LD_{50} = 10 mg/kg) and, therefore, may also be toxic to birds, avian acute and subacute dietary testing were required at that time. However, subsequent to EFED's data request, the manufacturing process was changed so that the formulation of diazinon no longer contains sulfotepp. Thus, special testing on sulfotepp is no longer required.

As indicated in Table 34, an apparently less sensitive species to diazinon's toxic effects is the bullfrog. A study conducted by Hudson and others (1984) with the bullfrog as a test species indicates that diazinon is practically nontoxic to this terrestrial-phase amphibian. Regarding birds, however, the LD_{50} values range from 1.44- to-69 mg a.i./kg; therefore, diazinon is categorized as very highly to moderately toxic to birds (and reptiles) on an acute oral basis.

In addition, researchers at the Patuxent Wildlife Research Center of the US Fish and Wildlife Service tested 9-week-old bobwhite quail from eight different game farms to determine whether species variability would impact the reproducibility of the acute toxicity results. By incubating the eggs and rearing the chicks to test age for all stocks simultaneously in the same facilities at Patuxent, extraneous variables associated with interlaboratory differences in husbandry were eliminated. Their findings were that under this single set of conditions, the toxic response to diazinon by these eight stocks of bobwhite were statistically inseparable. The pooled LD_{50} for the eight stocks was 14.7 mg/kg with a 95 % confidence interval of 13.1-to-16.5 mg/kg (Hill et al., 1984).

Bird acute symptoms are goose-stepping ataxia, wing spasms, wing drop, hunched back, dyspnea, tenesmus, diarrhea, salivation, lacrimation, ptosis of eyelid, prostration, opisthotonos-like seizures or wing-beat convulsions. The No Observed Adverse Effect Level (NOAEL) represents an exposure level, at or below which biologically significant effects will not occur to species of similar sensitivities. One or more of the following resulted in a supplemental determination for some of the submitted studies: the tested subjects were nonpreferred test species; test subjects experienced extensive regurgitation of the test substance; the age and sex of tested species were not reported; the confidence interval for the LD_{50} determination was unacceptable; the test methods were inappropriate resulting in a failure to produce a definitive LD_{50}; the tested birds were too young; incorrect sex ratios of the tested species were used and/or test protocols were not followed. The core studies were scientifically sound and met protocol requirements. The guideline (71-1) is fulfilled (ACs 240993, RO0DI001 and RO0DI002, FEODIA01 through FEODIA08, and MRIDs 0020560, 0160000, 00109015, 40895303, 40895305, 40895306, 40895307 and 40895309).

Two dietary studies using the TGAI are required to establish the toxicity of diazinon to birds. These avian dietary LC_{50} tests, using the Mallard Duck and Bobwhite Quail, are acute, eight-day dietary laboratory studies designed to estimate the quantities of toxicant required to cause 50% mortality in the two respective test populations of birds. The TGAI is administered by mixture to juvenile birds' diets for five days followed by three days of "clean" diet, and the results are expressed as LC_{50} parts per million (ppm) active ingredient (a.i.) in the diet. Toxicity category descriptions are the following:

If the LC_{50} is *less than 50 ppm a.i.*, then the test substance is *very highly toxic*.
If the LC_{50} is *50-to-500 ppm a.i.*, then the test substance is *highly toxic.*
If the LC_{50} is *501-to-1,000 ppm a.i.*, then the test substance is *moderately toxic.*
If the LC_{50} is *1001-to-5,000 ppm a.i.*, then the test substance is *slightly toxic.*
If the LC_{50} is *greater than 5,000 ppm a.i.*, then the test substance is *practically nontoxic.*

Results of these tests are tabulated below. The toxicity value (LC_{50}) appearing in the shaded area of the table will be used to calculate the acute avian risk quotients (RQ) in following sections.

Table 36: Avian (also Reptilian and Terrestrial-Phase Amphibian) Subacute Dietary Toxicity - Technical

Species	% ai	LC50(ppm)	Toxicity Category	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Brown-headed Cowbirds *(Molothrus ater)*	88.2	LC_{50}= 38 NOAEL= 8	very highly toxic	40895304/Fletcher, D. & C. Pedersen/1988	Supplemental
Canada Goose(*Branta canadensis)*	86.6	3,912	slightly toxic	FEODIA11/Grimes, J. & M. Jaber/1987[a]	Supplemental
Japanese Quail*(Coturnix japonica*)	99.0	167	highly toxic	ROODI003/Hill, E. & M. Camardese/1986	Supplemental
Japanese Quail*(Coturnix japonica*)	99.0	47	very highly toxic	00034769/Hill E., et.al./1975	Supplemental
Mallard Duck *(Anas platyrhynchos*)	88.2	LC_{50}= 32 NOAEL= 16	very highly toxic	40895302/Fletcher, D. & C. Pedersen/1988	Core
Mallard Duck*(Anas platyrhynchos*)	99.0	191	highly toxic	00034769/Hill E., et.al./1975	Core
Mallard Duck*(Anas platyrhynchos)*	86.6	59.6	highly toxic	FEODIA10/Wild Life Int./1987[a]	Supplemental
Mallard Duck*(Anas platyrhynchos)*	86.6	<47	very highly toxic	FEODIA09/Grimes, J. & M. Jaber/1987[a]	Supplemental
Northern Bobwhite Quail *(Colinus virginianus*)	99.0	245	highly toxic	00034769/Hill E., et.al./1975	Core
Ring-necked Pheasant *(Phasianus colchicus)*	99.0	244	highly toxic	00034769/Hill E., et.al./1975	Supplemental

[a] Reviews by L. Turner (EPA) for 1987 Diazinon hearing FIFRA Docket Nos. 562, et al.

Table 37: Avian (Reptilian and Terrestrial-Phase Amphibian) Subacute Dietary Toxicity - End Use Formulations

Species	% ai	LC50 (ppm)	Toxicity Category	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Mallard Duck *(Anas platyrhynchos*)/Emulsifiable Concentrate	48.1	LC_{50}= 38 NOAEL= 8	very highly toxic	40895308/Fletcher, D. & C. Pedersen/1988	Core
Mallard Duck *(Anas platyrhynchos)/*Emulsifiable Concentrate	48.6	180	highly toxic	00104923/AC228039/ Woodard Research Corp./1965	Supplemental
Mallard Duck*(Anas platyrhynchos*) Microencapsulated	23.0	LC_{50}= 649 NOAEL=<23	moderately toxic	AC240993/Beavers, J./1978c	Core
Mallard Duck *(Anas platyrhynchos)/* Microencapsulated	23.0	1,503	slightly toxic	AC240993/Beavers, J./1978b	Core
Mallard Duck *(Anas platyrhynchos*) Microencapsulated	23.0	149 (C.L. 107-209)[2]	highly toxic	RO0DI004/Pennwalt/1979	Supplemental
Northern Bobwhite Quail *(Colinus virginianus*)/Microencapsulated	23.0	345	highly toxic	RO0DI004/Pennwalt/1979	Supplemental
Northern Bobwhite Quail *(Colinus virginianus*)/Emulsifiable Concentrate	48.6	LC_{50}= 140 NOAEL= <80	highly toxic	00104923/AC228039/ Woodard Research Corp./1965	Supplemental
Brown-headed Cowbirds *(Molothrus ater)*Emulsifiable Concentrate	48.1	LC_{50}= 42 NOAEL=16	very highly toxic	40895310/Fletcher, D. & C. Pedersen/1988	Supplemental
Japanese Quail *(Coturnix japonica*)/Emulsifiable Concentrate	48.0	101	highly toxic	ROODI003/Hill, E. & M. Camardese/1986	Supplemental
Mallard Duck *(Anas platyrhynchos*)/Wettable Powder	53.0	180 (C.L. 107-209)[2]	highly toxic	RO0DI004/Pennwalt/1979	Supplemental
Northern Bobwhite Quail *(Colinus virginianus*)/Wettable Powder	53.0	140 (C.L. 97-205)[2]	highly toxic	00104923/Woodard Res. Corp./1964	Supplemental

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline)

[2] C.L. is the 95% confidence limits, the upper and lower boundaries, of which one is 95 percent confident that the statistically derived $LD_{50,}$ is between these values.

Because the LC_{50} falls in the range of 32 to 3,912 ppm, diazinon is categorized very highly to slightly toxic to avian species on a subacute dietary basis. One or more of the following resulted in a supplemental determination for some of the submitted studies: the tested subjects were nonpreferred test species; test subjects experienced extensive regurgitation of the test substance; the age of the tested species was unacceptable; the confidence interval for the LD_{50} determination was unacceptable; and/or the test methods were inappropriate resulting in a failure to produce a definitive LD_{50}. The core studies were scientifically sound and met protocol requirements. The guideline (71-2) is fulfilled (MRIDs 40895302, 00034769, and 40895308, and AC's 104923, 240993, RO0DI003, and RO0DI004).

ii. Birds, Chronic

Avian reproduction studies using the Bobwhite Quail and Mallard duck are laboratory tests designed to estimate the quantity of toxicant required to adversely affect the reproductive capabilities of a test population of birds. The TGAI is administered by mixture to breeding birds' diets throughout their breeding cycle. Test birds are approaching their first breeding season and, generally, are 18-to-23 weeks old. The onset of the exposure period is at least 10 weeks prior to egg laying. Exposure period during egg laying is generally 10 weeks with a withdrawal period of three additional weeks if reduced egg laying is noted. Results are expressed as No Observed Adverse Effect Level (NOAEL) and various observable effect levels, such as the Lowest Observable Adverse Effect Level (LOAEL), quantified in units of parts per million of active ingredient (ppm a.i.) in the diet.

Avian reproduction studies using the TGAI are required for diazinon because the following conditions are met: (1) birds may be subject to repeated or continuous exposure to the pesticide, especially preceding or during the breeding season, (2) the pesticide is stable in the environment to the extent that potentially toxic amounts may persist in animal feed, (3) the pesticide is stored or accumulated in plant or animal tissues, and/or, (4) information derived from mammalian reproduction studies indicates reproduction in terrestrial vertebrates may be adversely affected by the anticipated use of the product. The preferred test species are mallard duck and bobwhite quail. Results of these tests are tabulated below in Table 37. The toxicity value (NOAEC) appearing in the shaded area of the table will be used to calculate the chronic avian risk quotients (RQ) in following sections.

Table 38: Avian (Reptilian & Terrestrial-Phase Amphibian) Reproduction - Technical & End-Use Formulations

Species/ Study Duration	% ai	NOAEC/ LOEC (ppm)	LOEC Endpoints	MRID/Accession (AC) No. Author/Year	Study Classification[1]
			Technical		
Mallard Duck *(Anas platyrhynchos)*/one generation	100.0	8.3/16.33	Significant reduction in the number of 14-day hatchling survivors.	41322901/Marselas, G./1989	Core[2]
Northern Bobwhite Quail *(Colinus virginianus)*/one generation	100.0	32.0/ >32.0	n/a	41322902/Marselas, G./1989	Core[2]
			End-Use Formulations		
Northern Bobwhite Quail *(Colinus virginianus)*/ one generation/ EC	48.0	35.0/Not Reported	Weight loss; reduced egg production	RO0DI010/Stromborg/ 1981	Supplemental
Ring-necked Pheasant *(Phasianus colchicus)*/ Treated Seed	--	1.05-2.1 mg a.i./day/Not Reported	weight loss and reduced egg production	00104083/Stromborg / 1975	Supplemental

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline).

[2] Parental as opposed to incubator incubation was required in the study.

A statistically significant reduction in the number of 14-Day hatchlings occurred when Mallard Duck mated pairs were fed diets containing 16.3 ppm or greater of diazinon. The study involving Ring-neck Pheasant and treated seed indicated that when diazinon comprised 6-to-12 % of the test subjects' daily food intake they experienced weight loss and reduced egg production. Therefore, outdoor use resulting in exposure to birds at the NOAEC of 8.3 ppm or greater preceding or during the breeding season may cause reproductive effects. The guideline (71-4) is fulfilled (MRIDs 41322901 and 41322902 and AC's 104083 and RO0DI010).

iii. Mammals, Acute and Chronic

Wild mammal testing is required on a case-by-case basis, depending on the results of lower tier laboratory mammalian studies, intended use pattern and pertinent environmental fate characteristics. In most cases, rat or mouse toxicity values obtained from the Agency's Health Effects Division (HED) substitute for wild mammal testing. These toxicity values are reported below. The toxicity values (LD_{50}, NOAEL,& LOAEL) appearing in the shaded areas of the table will be used to calculate the acute and chronic mammalian risk quotients (RQ's) in subsequent sections. The guideline (71-4) is fulfilled.

If the LD_{50} is *less than 10 mg a.i./kg*, then the test substance is *very highly toxic*.
If the LD_{50} is *10-to-50 mg a.i./kg*, then the test substance is *highly toxic*.
If the LD_{50} is *51-to-500 mg a.i./kg*, then the test substance is *moderately toxic.*
If the LD_{50} is *501-to-2,000 mg a.i./kg*, then the test substance is *slightly toxic.*
If the LD_{50} is *greater than 2,000 mg a.i./kg*, then the test substance is *practically nontoxic.*

Table 39: Mammalian Toxicity

Species/ Study Duration	% ai	Test Type	Toxicity Value (mg/kg or ppm)	Affected Endpoints	MRID No.
laboratory rat (Rattus norvegicus)	25.0	Acute oral	LD_{50}= 1,100 (male) 1,258 (female)	mortality	00238762
laboratory rat (Rattus norvegicus)	% not reported (technical)	Acute oral	LD_{50}=775 (male) 499 (female) 618 (combined)	mortality	00146179
laboratory rat (Rattus norvegicus)	87.0	Acute oral	LD_{50}=505 (combined)	mortality	41407202
laboratory rat (Rattus norvegicus)	50.0	Acute oral	LD_{50}=2,000 (male) 1,940 (female) 1,960 (combined)	mortality	41407210
laboratory rat (Rattus norvegicus)	48.0	Acute oral	LD_{50}= 1,935 (male) 2,229 (female)	mortality	41332609
laboratory rat (Rattus norvegicus)	47.5	Acute oral	LD_{50}= 1,723 (male) 1,503 (female)	mortality	41332616
laboratory rat (Rattus norvegicus)	25.0	Acute oral	LD_{50}= 2,240 (male) 1,470 (female)	mortality	41137003

An analysis of the results indicate that diazinon is categorized as moderately to practically nontoxic to small mammals on an acute oral basis.

Acute Dermal and Inhalation Toxicity Testing. In addition to acute oral routes of exposure, terrestrial vertebrates entering the field after treatment may be acutely exposed to diazinon. Toxicity category descriptions associated with dermal routes of exposure include the following:

If the LD_{50} is *less than or equal to 200 mg a.i./kg*, then the test substance is *very highly toxic*.
If the LD_{50} is *greater than 200 through 2,000 mg a.i./kg*, then the test substance is *highly toxic*.
If the LD_{50} is *greater than 2,000 through 20,000 mg a.i./kg*, then the test substance is *moderately to slightly toxic.*
If the LD_{50} is *greater than 20,000 mg a.i./kg*, then the test substance is *practically nontoxic.*

Table 40: Mammalian Dermal Toxicity (LD_{50})

Surrogate Species/ Formulation	% A.I.	LD_{50} (mg/kg)	Toxicity Category	MRID No.	Study Classification
Laboratory Rat (*Rattus norvegicus*)/ Technical	% Not Reported	>2,150	moderately toxic	00228039/Novartis, Inc. 1679; 25-May-1972 2	Supplemental
Laboratory Rat (*Rattus norvegicus*)/	% Not Reported	900 (740-1,107), male 456 (379-546), female	highly toxic	00005567/Toxicology and Applied Pharmacology 2:88-99	Supplemental

The results indicate that diazinon is highly toxic to mammals on an acute dermal basis. Overt signs of toxicity were increased salivation, nasal discharge, diarrhea, and muscle tremors (MRID 00228039 and 00005567).

The acute inhalation toxicity results for diazinon are indicated in Table 39 below. Toxicity category descriptions associated with inhalation routes of exposure the following:

If the LC_{50} is *less than or equal to 200 mg a..i./m^3*, then the test substance is *very highly toxic*.
If the LC_{50} is *greater than 200 mg a.i. /m^3 through 2,000 mg a.i./m^3*, then the test substance is *highly toxic*.
If the LC_{50} is *greater than 2,000 mg a..i./m^3 through 20,000 mg a.i./m^3*, then the test substance is *moderately to slightly toxic.*
If the LC_{50} is *greater than 20,000 mg a.i./m^3*, then the test substance is *practically nontoxic.*

Diazinon is very highly toxic to mammals when fumes are inhaled at 3.5 milligrams per cubic meter directly after application. Overt signs of toxicity are increased salivation, nasal discharge, diarrhea, muscle tremors and death. This study is scientifically sound but did not meet minimum guideline requirements and is classified supplemental (MRIDs 00228039 and 00005567).

Table 41: Mammalian Inhalation Toxicity (LC_{50})

Surrogate Species/ Formulation	% A.I.	LC_{50} (mg/meter^3	Toxicity Category	MRID No.	Study Classification
Laboratory Rat (*Rattus norvegicus*)/Technical	% Not Reported	3.5 (3.08-3.97)	very highly toxic	00228039 and 00005567 Novartis, Inc. SISS 1679; 25-Apr-1972	Supplemental

Mammalian Subchronic Toxicity Testing. The submitted mammalian subchronic feeding studies indicate that extended exposure to diazinon residues via the diet at levels greater than) 0.8 ppm will cause vomiting, decreased food consumption and body weight, and increased mortality in mammals. However, blood and plasma cholinesterase of exposed mammals will be depressed at dietary residues greater than 0.3 ppm. The toxicity value (NOAEL) appearing in the shaded area of the table following will be used to calculate the mammalian chronic risk quotients (RQ's) in subsequent sections.

Table 42: Mammalian Subchronic Toxicity

Surrogate Species/ Exposure Duration	% ai	NOAEL/LOAEL (ppm)	LOAEL Endpoints	MRID No. Author/Year	Study Classificatio
Laboratory rat (*Rattus norvegicus*)/ Not Reported	% Not Reporte d	<2/Not Reported for Cholinesterase Depression	Cholinesterase inhibition	005567/Toxicology & Applied Pharmacology 54:359-367	Supplementa l
Laboratory rat (*Rattus norvegicus*)/ Not Reported	87.0	0.3/30 for Plasma and Red Blood Cell Cholinesterase Depression 30/300 for Brain Cholinesterase Depression	Cholinesterase inhibition	43543901/ Novartis, Inc./ F-00186; 17 Nov 1994	Core
Domestic Dog (*Canis familiaris*) 28 Days	87.7	0.80/14.68 for Systemic Effects ND/<0.023 for Cholinesterase Depression	Emesis (Vomiting), Decreased Body Weight and Food Consumption Cholinesterase inhibition	0088077/Novartis, Inc. (MIN 872349) 01-Aug-1988	Supplementa l

ND = Not Determined

Mammalian Reproductive and Developmental Toxicity Testing. As indicated in the following table, treatment-related effects involved decreased food consumption and body weight gain and increased mortality in the offspring when the mother rat was exposed to daily doses of 20 milligrams per kilogram of her body weight (mg/kg/day) or greater for 10 days during gestation (pregnancy). The submitted mammalian 2-generation reproduction study using laboratory rats as the test subjects indicates dose-related decreases in parental and pup body weight and pup mortality at the parent's dietary intake levels which exceeded 10 ppm (MRID 00015301 and 41158101).

Table 43: Mammalian Developmental and Reproductive Toxicity

Surrogate Species/	%ai	NOAEL/LOAEL	LOAEL Endpoints	MRID No.	Study
			Developmental Effects		
laboratory rat (Rattus norvegicus)	% not reported (technical)	NOAEL= 20 ppm (maternal) LOAEL= 100 ppm (maternal)	decreased food consumption and body weight gain	000153017/Novartis/ 19-Apr-1985	Core
			Reproductive Effects		
laboratory rat (Rattus norvegicus)	94.9	NOAEL= 10 ppm (parental & dev.) LOAEL= 100 ppm (parental & dev.)	Decreased parental & pup weight.gain. Pup mortality	41158101/Novartis/ 09-Feb-1989	Core

iv. Beneficial Insects

A honey bee acute contact study using the TGAI is required for diazinon because its use will result in honey bee exposure. The acute contact LD_{50}, using the honey bee, *Apis mellifera*, is an acute single-dose laboratory study designed to estimate the quantity of toxicant required to cause 50% mortality in a test population of bees. The TGAI is administered by one of two methods: whole body exposure to technical pesticide in a nontoxic dust diluent; or, topical exposure to technical pesticide via micro-applicator. The median lethal dose (LD_{50}) is expressed in micrograms of active ingredient per bee (µg a.i./bee). Results of this test are tabulated below. Toxicity category descriptions are the following:

If the LD_{50} is *less than 2* µg a.i./bee, then the test substance is *highly toxic*.
If the LD_{50} is *2-to-11* µg a.i./bee, then the test substance is *moderately toxic.*
If the LD_{50} is *greater than 11* µg a.i./bee, then the test substance is *practically nontoxic*

Table 44: Nontarget Insect Acute Contact Toxicity

Species	**% ai**	**LD50 (µg a.i./bee)**	**Toxicity Category**	**MRID/Accession (AC) No. Author/Year**	**Study Classification[1]**
Honey bee *(Apis mellifera)*	not reported (Technical)	0.372	highly toxic	00036935/Atkins, E. et al./1975	Supplemental
Honey bee *(Apis mellifera)*	not reported (Technical)	0.2 (oral)	highly toxic	05004151/Stevenson, J./1968	Supplemental
Honey bee *(Apis mellifera)*	not reported (Technical)	0.22	highly toxic	05004151/Stevenson, J./1968	Core

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline).

An analysis of the results indicate that diazinon is categorized as highly toxic to bees and other beneficial insects on an acute contact basis. The guideline (141-1) is fulfilled (MRID# 05004151).

A honey bee toxicity of residues on foliage study is required on an end-use product for any pesticide intended for outdoor application, when the proposed use pattern indicates that honey bees may be exposed to the pesticide, and when the formulation contains one or more active ingredients having an acute contact honey bee LD_{50} which falls in the moderately toxic or highly toxic range. The purpose of this guideline study is to develop data on the residual toxicity to honey bees. The use pattern and high acute toxicity to honey bees of diazinon required the submission of this study. In the 1989 Registration Standard for diazinon, the Agency accepted the following studies in lieu of receiving a guideline study to fulfill this data requirement.

Table 45: Nontarget Insect Foliage Residue Contact Toxicity

Species	% ai	Application Rate (lb a.i./acre)	Time Between Application and Exposure (hours)	% Honey Bee Mortality After 1-Hour Exposure to Toxicant on Medium[1]	MRID/Accession (AC) No. Author/Year	Study Classification[2]
Honey bee *(Apis mellifera)*	40.0	1.0	18 42	100 100	05008936/Clinch, P./1967	Supplemental
Honey bee *(Apis mellifera)*	16.0	0.5	not reported	100	05004413/Palmer-Jones, T./1958	Supplemental

[1] Mortality assessed after 24 hours
[2] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline).

These studies are being downgraded from Core to Supplemental. These studies, which were performed in 1967 (MRID No. 05008936) and 1958 (MRID No. 05004413), do not provide an RT_{25}. The RT_{25} is the residual time it takes to result in a 25% or less mortality to honey bees exposed to treated foliage. Guideline 141-2 also requires that the studies be performed using the maximum application rate of a typical end-use product; these studies were not performed at the current maximum application rate of diazinon. Guideline 141-2 requires test samples to be collected 3, 8, and 24 hours after application. If mortality rates of bees exposed to 24-h-old residues is greater than 25 percent, sampling at 24-h intervals should continue until mortality of bees exposed to the treated foliage is not significantly greater than control mortality. These studies were not conducted according to current standards and do not provide the data necessary to determine how long diazinon residues on foliage remain toxic to exposed honey bees. The guideline (141-2) is not fulfilled.

vi. Terrestrial Field Testing

<u>Turf</u>

Five terrestrial field studies on turf were submitted to EPA and reviewed for the 1987 diazinon cancellation hearings regarding golf courses and sod farms. Four of these were on golf courses and one was on home lawns.

Sudden Valley, Washington Golf Course (Kendall et al., 1987). Eighty-five American wigeon were killed following one Diazinon AG500 application at a target 2 lbs a.i./A rate, to nine fairways, in October 1986. Investigators hazed birds to prevent still further mortality.

Turf residues after application and before irrigation on the day of application were reported from 183-363 ppm; after irrigation, reported values were 100-333 ppm. Catch-pan samples to measure actual application rates reportedly showed variation from 0.94-5.15 lb ai/A (mean = 2.6).
The wigeon died followed a reported feeding period of only 30-40 minutes, in the late afternoon on the application day. Diazinon residues in the GI tracts and severely depressed brain AChE levels confirmed diazinon as the cause of death.

The study clearly demonstrates the potential for severe mortality when birds feed intensively on treated turf. Despite the uneven application, <u>all</u> application day residue values on grass exceed the level of diazinon (47 ppm) reported to kill 100% of young mallards in the lab. Because of the hazing activity, the 85 reported wigeon deaths can only be considered a minimum--considerably more may have died if the study had continued as designated.

No search efficiency or scavenger removal estimates were made by the investigators. Hence, it is not known what proportion of actual mortality was found. Since carcass searches were conducted in the morning, mortalities of the previous day might have been missed if scavengers were active at night, for example.

The study was conducted during a migratory period, when there may have been a rapid turnover of individuals using the site. Except for gulls, it is not clearly reported in the census information whether birds were even on the treated areas, let alone feeding there. This was not a population study and birds were not marked or banded. The census data cannot be used to indicate little or no effect on species other than wigeon.

Birch Bay, Washington Sea Links Golf Course (Kendall et al., 1987). Three additional wigeon were killed in this spring, 1987 study, despite hazing tactics (including firecrackers) used to prevent their exposure. The study focused on Canada Geese. Despite a reported low proportion of time geese spent on the treating turf, 2-3 geese were observed with symptoms of organophosphate poisoning, almost certainly due to diazinon.

Diazinon was applied two times, seven days apart, at a target rate of 2 lb ai/A. The measured application rates were reportedly only 1.40-1.69 lb ai/A for the first application and 1.17-1.55 lb ai/A for the second application. Turf residues reported for the day of the first application were 102-135 ppm before irrigation and 33.2-55.6 after irrigation. Following spraying on the day of the second application, reported residues before and after irrigation were 134-215 ppm and 6.74-45.4 ppm, respectively.

This study demonstrates the potential for avian mortality, sickness, and incapacitation, despite a small area treated (approximately 2.5 acres), application rates consistently less than the reported intended rate, the hazing tactics, an adjacent unsearched marsh where sick or dying birds may have escaped detection, and the information that geese spent the majority of their time feeding in untreated areas. It seems likely that without these study deficiencies, the number of sick or dead birds reported could have been considerably higher.

Connecticut Study, Redding Country Club Golf Course (Palmer et al., 1987). Two diazinon applications at a tartget rate of 2 lb ai/A were made 7-8 days apart to 5 fairways, tees, and greens, followed by 0.25" irrigation. Turf residues following irrigation on the application day were reported to be 32.8-75.9 ppm for the first application and 38.8-95.2 for the second application. Canada geese were the focus of the study.

One goose showed signs of toxicity following the second application. The geese spent far more time, both before and after diazinon application, in <u>untreated</u> rough than in treated area. They spent <u>no time at all</u> on treated area on the application day, or on days 4, 5, 6, and 7 after the first application. The geese spent <u>no time at all</u> on the treated area on the day of the second application, or on days 2, 3, 4, and 5 following the second application.

The scavenger removal test showed heavy pressure: 87% of placed carcasses were removed within 72 hours of placement; 24 of 26 scavenged carcasses were removed at night; and 80% of placed mallard carcasses were removed by scavengers the first night after placement.

As with the above studies, this study demonstrates that residues, even after irrigation, can exceed the level lethal to 100% of mallards in lab studies, thereby indicating a substantial potential for hazard to any grazing waterfowl. The fact that only one goose showed signs of toxicity may well be related to the low exposure noted above. Feeding in untreated areas would not be expected to pose a hazard, of course. Carcass searches of fairways, tees, and greens were conducted in the morning. Given the high nighttime scavenger removal rate documented, a large percentage of any birds dying in the daytime may well have been removed at night before the next carcass search.

Virginia Study, Greendale Golf Course (Fletcher, 1987). Two diazinon applications at a target rate of 2 lb ai/A, 7 days apart, were made to 6 fairways in October 1986. Reported application day residues on turf were 113-144 ppm after irrigation following the first application, and 129-168 ppm after irrigation following the second application.

Behavioral effects in two robins were noted, but no avian mortality was reported. Extremely heavy scavenger removal of test carcasses were reported (e.g., 92% removal at 48 hours).

Unlike the above Sea Links and Connecticut studies, no documentation at all is made of the amount of time birds spent feeding on treated turf. While the report cites 11 species as seen on the treatment area, no information is provided as to how many individuals were exposed, whether they were feeding, or how long they were present on the treated turf.

Even if substantial exposure occurred (and there is no evidence that it did), the extremely high scavenger removal rate means that a large percentage of any resulting mortalities may not have been found. If scavenger removal occurred largely at night, any birds dying after a carcass search (and removed by scavengers) would not be seen in the next day's carcass search. For the days of application, this would include any bird dying more than four hours after early morning application, when the last carcass search was conducted. The days of application are particularly important because of the higher residues and risks usually present on these days.

Georgia Study (Mellott et al., 1987). This home and commercial lawn study involved application at a target rate of 4 lb ai/A of liquid and granular formulations, during October and November 1986. 34 residential front lawns and l commercial property were studied.

The report notes that "most species occurred infrequently on both study sites." Thirty-seven percent of the species observed at the residential site were seen on lawns, while only the blue jay was seen on the lawn at the commercial site. One carcass with diazinon residues was found, as well as other remains not suitable for analysis.

This study is seriously flawed and has little to contribute to the assessment of the risks of diazinon. Exposed birds could easily fly to any backyard or to numerous front yards not included in the study. Any sick or dying birds in these nearby areas would likely go undetected. No report was made of the actual time birds were exposed on turf, or even what the turf, insect, or seed residues were.

For most songbirds in most home lawn settings, consumption of contaminated insects by adults and young during the breeding season may present the greatest hazard from diazinon. Because this study was conducted in the fall, it could not possibly address this hazard. No carcass searches were conducted on the days of application, although residues and hence risk were likely greatest at this time.

South Carolina Studies on Urban Lawns (1989 and 1990). Screening studies were conducted during the fall, spring and summer in South Carolina to evaluate the potential for wildlife (primarily bird) mortality from an application of diazinon in the form of either D·z·n Diazinon 2G, 5G or D·z·n Diazinon AG500. These organophosphate insecticide formulations are used in the maintenance of turf against phytophagous soil invertebrate damage. In these studies, hazard was determined by assessing the potential for acute toxic effects on birds from exposure to these formulations. Avian mortality (and any other incidental animal mortality), species/frequency/number of birds utilizing urban lawns, affected-enzyme activity, and diazinon residue levels on grass, in soil, or in G.I. tracts of collected mortalities were the parameters that were quantified.

The test areas were located in upstate South Carolina around the metropolitan complex of Greenville, Spartanburg, and Anderson. This area was chosen due to known high bird densities as well as proximity to the conducting facility. These lawns (consisting of Bermuda and fescue grasses) fulfilled the criteria for reasonable biological diversity and adjacent habitat. The pH values, thatch depths, soil moistures, and organic matter contents were not significantly different among the respective lawns.

The granules were applied to the lawns using a spreader while the liquid formulation was applied with a hand-held sprayer (1:130 dilution in water). Containers were recessed in the lawns for both types of applications. The formulated material collected in these receptacles was assayed to confirm actual application rates.

Wildlife mortality was monitored by conducting casualty searches daily. The entire lawn was searched by one person walking transects which were spaced 5 meters apart. According to the reports, the rough edges of the site and shrubbery were also searched. The animal carcasses found during the searches were necropsied and gutted to determine gastrointestinal residues. Brain tissue was analyzed for cholinesterase activity. This assay was done with and without the addition of 2-PAM (a cholinesterase reactivator) in the incubation solution. A greater than or equal to 50-percent depression in brain cholinesterase activity and tissue G.I. tract residue presence together served as the defining factors to assume organophosphate-induced death.

Carcass detect ability tests were conducted to gauge both the ability of searchers to detect carcasses and the removal/hiding of carcasses by scavengers. Ten carcasses were placed per site, and the tests were conducted three times. However, according to the reports, the authors used the DREAP formula to determine the necessary area to obtain a 20% probability of a site showing an effect. However, the authors did not use the DREAP formula correctly. This formula specifies the factors to be considered when designing carcass searches on test sites. EPA's *Guidance Document for Conducting Terrestrial Field Studies* recommends that carcass searches be designed so that at least two carcasses (N=2) will be found if there is appreciable mortality. The submitted study set N equal to one. As a result, carcass searching was conducted on too small of an area for all three studies.

Soil samples (8 x 2 x 10 cm) were collected 1 day prior to application and one hour and 24 hours; 2, 4, 8, 12, and 16 days; and, in some instances, 24 days after application. The thatch layer was separated from the soil sample and treated as a separate sample. Grass clippings (0.25 m^2 quadrat) were also collected. Reference lawns were sampled similarly throughout the collection period. Samples were collected in quadruplicate. Analytical samples were extracted with solvents. The analysis of the parent compound (diazinon) or the metabolite diazoxon was accomplished using gas chromatography coupled with flame-photometric detection. The limit of detection for the diazinon procedure was either 0.005 ppm (soil), 0.05 ppm (thatch and 2G- and 5G-treated grass) or 0.5 ppm (AG500-treated grass). The limit of detection for the diazoxon procedure was either 0.01 ppm (soil), 0.1 ppm (thatch and 2G- and 5G-treated grass) or 1.0 ppm (AG500-treated grass). Residue levels were determined by computing the concentration from a standard curve. Sample spikes (with chlorpyrifos) were included in extraction sets to determine recovery. Sample blanks were included to assess spiking accuracy and account for any contamination.

Weather data were collected from the local airport. For the fall study, precipitation occurred during application and only two rainfall events greater than 1 cm (4.5 cm and 2 cm) occurred approximately 8 and 12 days after application, respectively. For spring and summer applications, weather data were collected from three weather stations located in or near the study area. Actual rainfall data were not provided. It was reported, however, that the mean monthly high/low temperature and precipitation deviated less than 10 percent from the previous 10-year average.

The principal statistical objective of the study was to demonstrate by the probability of the binomial random variable x (x being the number of sites showing effects) that diazinon applications affected 20 percent of the avian population or did not affect 80 percent of the population. For the spring application, the pH values, thatch depths, soil moistures, and organic matter contents of the soils at each site were subjected to analysis of variance or multiple analysis of variance (MANOVA). Application rates were compared using a t-test. Soil and grass diazinon decay rates were compared using analysis of covariance. Diazinon degradate and cholinesterase assay results as well as nestling survival rate were also compared using MANOVA. For the summer application, soil and grass diazinon decay rates were compared using analyses of covariance. Avian mortality was compared using the Kruskal-Wallis test.

Conclusions. Although no conclusions could be drawn about the fall application of diazinon to turf, the submitted data provided some insights about adverse effects to birds from the spring and summer diazinon applications to turf. Birds most impacted by diazinon 2G and 5G applications and, to a lesser degree, AG500 applications, as indicated by the results, are species which forage on turf for insects and seeds. They are blackbirds, cowbirds, grackles, and meadowlarks in the family, Icteridae, and starlings in the family, Sturnidae. These bird species are all known inhabitants of parks, farms, open groves and fields throughout most of the United States thereby increasing the likelihood of their exposure to applied pesticides where turf is maintained.

In addition, the enzyme and chemical assays from the spring application of diazinon indicate that exposure is occurring to both adult birds and nestlings and that exposure was greater for birds utilizing the granular-treatment sites. The carcass searches, coupled with the censussing and efficiency/removal tests from the summer application of diazinon also demonstrated that mortality was significantly elevated in response to granular diazinon.

As indicated in the table below, there is little margin for safety for ground foragers like sparrows and blackbirds after an application of diazinon 14G. Similarly, a droplet with a general size of 0.05 ml of diazinon 50 WP or 48EC will contain approximately 2.5 mg of diazinon.

Table 46: Number of 14 G Granules Equivalent to the LD_{50} for Three Avian Species

Species	Body Weight (G)	LD_{50} mg/Animal	MRID/Accession (AC) No. Author/Year	No. 14G Granules*
House Sparrow	20	0.15	RO0DI001/Balcomb et al./1984	3.24
Redwing Blackbird	50	0.16	RO0DI001/Balcomb et al./1984	3.45
Brown-Headed Cowbird	43	3.0	RO0DI001/Balcomb et al./1984	64.74

(6) Based on an average weight of 0.331 mg, each granule containing approximately 0.046 mg (14%) diazinon.

Regarding other nontarget effects, a few small mammals and amphibians were found dead on treatment and control sites during the course of these studies. However, the percentage, if any, of treatment-related deaths is uncertain because only a few carcasses were necropsied but without conclusive results.

Carrots

Submitted laboratory data indicate that diazinon is very highly toxic to birds; two level-one field studies were conducted to rebut EPA's presumption of risks to birds and other wildlife from the use of DZN diazinon 14G at a rate of 4 lbs ai/acre on carrot fields.

Texas Study (Fletcher, 1990). In the fall of 1989 at treatment sites located in southern Texas, DZN diazinon 14G was broadcast and worked into the soil to a depth of 2-to-8 inches prior to planting. EN-CAS Laboratories analyzed samples of soil, water, invertebrates, and birds to determine parent residue levels in each sample. Sample analyses yielded residue values ranging from <0.05-to-76 ppm for soil; <0.05 ppm for water; <0.10-to-2.0 ppm for invertebrates; <0.05-to-2.0 ppm for avian carcass; and <0.05-to-92 ppm for avian gastrointestinal (GI) tract.

Conclusions: The report indicates that four bird carcasses were found during the study, but the report only attributes one of the deaths to diazinon, due to 92 ppm found in the GI tract. It is unknown whether the other birds died from diazinon exposure or other causes. Soil incorporation which reduced exposure to the diazinon granules best explains these findings (MRID 415802-01).

Wisconsin Study (Fletcher 1990). In the spring of 1989 at treatment sites located in southeastern Wisconsin, DZN diazinon 14G was broadcast and worked into the soil to a depth of 2-to-8 inches prior to planting. On post-application day 1, soil residues averaged 9.61 ppm and on post-application day 3, they averaged 10.11 ppm.

Conclusions: The report indicates that one intact bird carcass was found during the study, and it contained a less than detectable level of diazinon. A dead mouse found on a test plot also contained no detectable levels in its muscle tissues and 0.059 ppm diazinon in its GI tract. It is unknown whether these animals died from diazinon exposure or other causes. A high carcass search efficiency and low carcass removal rate were reported. Soil incorporation which reduced exposure to the diazinon granules best explains these findings (MRID 415352-01).

Cabbage

Although a study protocol for DZN AG500 applications to cabbage fields was submitted, a field study was not conducted/submitted. DZN AG500 usage on cabbage is primarily for the prevention and control of aphids, diamondback moths and imported cabbageworms. Because DZN AG500 is applied as a foliar spray at a rate of 0.5-to-0.75 lbs ai/acre, the potential exposure to wildlife would be more significant, and hence, would have been more valuable in determining wildlife risks than the submitted studies involving applications of soil incorporated diazinon 14G to carrot fields.

Apples

Eastern Washington and Pennsylvania Study (Kendall, 1990). During the spring of 1989, screening studies were conducted in Washington and Pennsylvania to evaluate the potential for wildlife mortality from an application of diazinon in the form of DZN 50W. This wettable powder formulation is used on apples to control various phytophagous invertebrates. DZN 50W was applied five/six times at a rate of 3 lbs ai/acre using an air blast sprayer.

Conclusions: Avian diversity was noted at both sites but most species were neither abundant nor frequently observed; nevertheless, the observations support the conclusion that DZN 50W application cause substantial adverse effects upon resident wildlife. In Pennsylvania, 127 avian, 24 mammalian, and 9 reptilian/amphibian mortalities were collected. In Washington, 260 avian, 46 mammalian, and 26 reptilian mortalities were collected. The study author's conclusions were that avian populations tended to be sub-lethally exposed (with the exception of killdeer and Canadian geese collected in Washington state), while mammal and reptile/amphibian populations appeared to be lethally exposed.

Based on the study results, the author also concluded that (1) water in and around ponds have the potential for chronic low-level exposure, (2) earthworms have the potential to cause secondary poisoning to predators (i.e. American robin), (3) ten-to-thirty-five percent of blue jay, common grackle, mourning dove and northern cardinal samples were recorded as having depressed enzyme activities, (4) the potential risks to birds is proportional to their foraging/reproduction effort in the orchards, (5) potential risks are high to mammals, especially voles, shrews, gophers, and mice, and (6) exposure to reptiles/amphibians is extensive; hence, the potential risks to reptiles/amphibians are highest of all wildlife species exposed to applications of DZN 50W (MRID 415774-01).

Corn

Iowa Study (Johnson, 1990). In 1989, screening studies were conducted in southern Iowa to evaluate the potential for wildlife mortality from an application of diazinon in the form of DZN 14G. This granular formulation was applied twice aerially over a 7-day period to eight sites at a rate of 2 lbs ai/acre for control of European corn borer. These sites were considered abundant in species richness and diversity: 72 species of birds, 10 species of mammals, and 7 species of reptilians and amphibians were observed in the corn fields.

Conclusions: Of the 70 casualties, 62 were birds representing 14 different species, 6 were mammals representing 4 different species, and 2 were reptiles representing 2 different species. Of these, 15 were regarded as treatment related, 19 were considered probably treatment related, 29 were presumed possible treatment-related, and 7 were considered not treatment related. Diazinon residues were found in the gut of all 15 mortalities considered treatment-related deaths, while "probables" were categorized based on behavioral observations. However, results from the carcass detectability study indicated an overall mean recovery rate of only 15 percent. In addition, brown thrasher, American robin, and blue jays utilized the corn fields most often and, therefore, were the songbirds most at risks from diazinon applications (MRID 415147-01).

Hence, these observations and residue data support the conclusion that DZN 14G applications may cause substantial adverse effects upon the resident wildlife. Diazinon half-live in the field soil was 6 days.

Eastern Maryland. In 1990, screening studies were also conducted in Queen Anne's county, Maryland, to evaluate the potential for wildlife mortality from an application of diazinon in the form of DZN 14G. The report indicates that corn fields are numerous and contribute to some of the highest quail densities in the state. These sites were considered abundant in species richness and diversity: 21 species of birds, 13 species of mammals, 3 species of reptiles, and 3 species of amphibians were observed in the corn fields.

Conclusions: Of the 56 casualties, 46 were birds representing 13 different species and 10 were mammals representing 6 different species. Of these, 22 were regarded as treatment related, 6 were considered probably treatment related, 15 were presumed possible treatment-related, and 13 were considered not treatment related. Diazinon residues were found in the gut of all 22 mortalities considered treatment-related deaths, while "probables" were categorized based on behavioral observations. However, results from the carcass detectability study indicated an overall mean recovery rate of only 20 percent. Hence, these observations and residue data support the conclusion that DZN 14G applications may cause substantial adverse effects upon the resident wildlife (MRID 415110-01).

b. Toxicity to Freshwater Aquatic Animals

i. Freshwater Fish, Acute

Two freshwater fish toxicity studies using the TGAI are required to establish the toxicity of diazinon to fish. The preferred test species are rainbow trout (a coldwater fish) and bluegill sunfish (a warmwater fish). Results of these tests are tabulated below. The toxicity category descriptions for freshwater and estuarine/marine fish and aquatic invertebrates, are defined below in parts per million (ppm), the standard units of measure; however, due to the extreme toxicity of diazinon to aquatic animals, the LC_{50} values and the Confidence Intervals (C.I.) represented in the following tables are in units of parts per billion (ppb). One ppm equals 1,000 ppb. The toxicity values (LC_{50}) appearing in the shaded area of the tables will be used to calculate the acute aquatic risk quotients (RQ's) in subsequent sections.

If the LC_{50} is *less than 0.1 ppm a.i.*, then the test substance is *very highly toxic*.
If the LC_{50} is *0.1-to-1.0 ppm a.i.*, then the test substance is *highly toxic*.
If the LC_{50} is *greater than 1 and up through 10 ppm a.i.*, then the test substance is *moderately toxic.*
If the LC_{50} is *greater than 10 and up through 100 ppm a.i.*, then the test substance is *slightly toxic.*
If the LC_{50} is *greater than 100 ppm a.i.*, then the test substance is *practically nontoxic.*

Table 47: Freshwater Fish Acute Toxicity - Diazinon Technical

Species/ Flow-through or Static	% ai	LC_{50} (ppb) / (C.I.)	Toxicity Category	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Bluegill Sunfish *(Lepomis macrochirus)*/not reported	91.0	136/ (100-186)	highly toxic	00104923/AC228039/Woodard Research Corp./1965	Supplemental
Bluegill Sunfish *(Lepomis macrochirus)*/flow-through	92.5	460/ (not reported)	highly toxic	ROODI007/Allison, D.T. & D.T. Hermanutz/1977	Core
Bluegill Sunfish *(Lepomis macrochirus)*/not reported	92.0	168/ (120-220)	highly toxic	40094602/Johnson, W. & M. Finley/1980	Supplemental
Brook Trout *(Salvelinus fontinalis)*/flow-through	92.5	770/ (not reported)	highly toxic	ROODI007/Allison, D.T. & D.T. Hermanutz/1977	Supplemental[2]
Cutthroat Trout *(Oncorhynchus clarki)*/not reported	92.0	1,700/ (1,390-2,090)	highly toxic	40094602/Johnson, W. & M. Finley/1980	Supplemental
Fathead Minnow *(Pimephales promelas)*/flow-through	92.5	7800/ (not reported)	moderately toxic	ROODI007/Allison, D.T. & D.T. Hermanutz/1977	Supplemental[2]
Flagfish *(Jordanella floridae)*/flow-through	92.5	1600/ (not reported)	moderately toxic	ROODI007/Allison, D.T. & D.T. Hermanutz/1977	Supplemental[2]
Guppy *(Lebistes reticulatus)/not reported*	not reported	1100/ (not reported)	moderately toxic	05000811/Rongsriyam, Y., et.al./1968	Supplemental
Lake Trout *(Salvelinus namaycush)*/not reported	92.0	602/ (400-906)	highly toxic	40094602/Johnson, W. & M. Finley/1980	Supplemental
Rainbow Trout (*Salmo gairdneri*)/not reported	89.0	90.0/ (not reported)	very highly toxic	40094602/Johnson, W. & M. Finley/1980	Supplemental
Rainbow Trout *(Oncorhynchus sp.)*/not reported	91.0	400/ (230-700)	highly toxic	00104923/AC228039/ Woodard Research Corp./1965	Supplemental

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline).

[2] Indicated as Core on the DER but changed, in this table, to Supplemental because of test species.

Table 48: Freshwater Fish Acute Toxicity - Diazinon End-Use Formulations

Species/Flow-through or Static/ Formulation	% ai	LC_{50} (ppb) / (C.I.)	Toxicity Category	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Bluegill Sunfish *(Lepomis macrochirus)*/Static/ Emulsifiable Concentrate	48.0	LC_{50}= 220/(170-320) NOEC= <55	highly toxic	40509802/Surprenant, D./1987	Core

Table 48: Freshwater Fish Acute Toxicity - Diazinon End-Use Formulations

Species/Flow-through or Static/ Formulation	% ai	LC_{50} (ppb) / (C.I.)	Toxicity Category	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Bluegill Sunfish *(Lepomis macrochirus)*/Static/ Microencapsulated	23.0	512.0/ (392.0-672.0)	highly toxic	AC240993/Calmbacher, C.W./1978b)	Core
Rainbow Trout (*O. mykiss)*/Static/ Emulsifiable Concentrate	48.0	LC_{50}= 1800/(1400-2900) NOEC= 230	moderately toxic	40509801/Surprenant, D./1987	Core
Rainbow Trout (*O. mykiss)*/Static/ Microencapsulated	23.0	635.0 (420.0-960.0)	highly toxic	AC240993/Calmbacher, C.W./1978a)	Core

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline).

Since the LC_{50} falls in the range of 90-to-7,800 ppb, diazinon is categorized very highly to moderately toxic to freshwater fish on an acute basis. The supplemental studies were not conducted according to acceptable protocols: the test species was not a preferred test species; water temperature was not within specifications; the information was provided as a reference source with no supporting data or statistical analysis; there were an insufficient number of mortality levels for calculating LC_{50}; and/or there was incomplete information provided in protocol. The guideline (72-1) is partially fulfilled (AC# ROODI007).

ii. Freshwater Fish, Chronic

A freshwater fish early life-stage test using the TGAI is required for diazinon because the end-use product is expected to be transported to water from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent, (2) any aquatic acute LC_{50} or EC_{50} is less than 1ppm, and (3) the EEC in water is equal to or greater than 0.01 of any acute LC_{50} or EC_{50} value. The preferred test species is rainbow trout. Results of this test are tabulated below.

The fish early life-stage is a laboratory test designed to estimate the quantity of toxicant required to adversely effect the reproductive capabilities of a test population of fish. The test should be performed using flow-through conditions. The TGAI is administered into water containing the test species, providing exposure throughout a critical life-stage, and the results, generally, are expressed as a No Observed Adverse Effect Concentration (NOAEC) in parts per million of active ingredient. However, due to diazinon's toxicity, the NOAEC and LOAEC (Lowest Observed Adverse Effect Concentration) units will be expressed in parts per billion a.i. (1 ppm = 1,000 ppb). The No Observed Adverse Effect Concentration represents an exposure concentration, at or below which biologically significant effects will not occur to species of similar sensitivities. The preferred test species is rainbow trout. The toxicity values (NOAEC) appearing in the shaded area of the table will be used to calculate the chronic aquatic risk quotients (RQ's) in subsequent sections.

Table 49: Freshwater Fish Early Life-Stage Toxicity Under Flow-through Conditions - Diazinon Technical

Species/ Study Duration	% ai	NOEC/LOEC (ppb)	Endpoints Affected	MRID/Accession (AC) No. Author/Year	Study[1] Classification
Brook Trout *(Salvelinus fontinalis)*/8 months	92.5	<0.55/<0.55	inhibited growth first 3 months, neurological symptoms, reduced growth in progeny	ROODI007/Allison, D.T. & D.T. Hermanutz/1977	Supplemental[2]
Fathead minnow *(Pimephales promelas)*/34 days	87.7	<92/not determined	adverse effects on larvae length and weight at all concentations tested	40782301/Suprenant, D./1988	Supplemental
Fathead Minnow *(Pimephales promelas)*/25 days	92.5	<3.2/not determined	significant scoliosis in F_1 generation and reduced hatch in F_2 generation	ROODI007/Allison, D.T. & D.T. Hermanutz/1977	Supplemental[3]

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline).

[2] Indicated as Core on the DER but changed, in this table, to Supplemental becauseNOAEC/LOEC not determined.

Since a definitive NOAEC and LOAEC was not determined on any of these studies, the guideline (72-4) not fulfilled. The supplemental studies were not conducted according to acceptable protocols: the dilution water had a low water hardness; incorrect light intensity was employed; the method of obtaining fertilized eggs from the culture was not provided; there were an inadequate number of replications; there was a failure to discontinue fish feeding 24 hours prior to the termination of the test; incorrect statistical analyses were performed; and/or NOAEC/LOEC were not determined.

A freshwater fish early life-cycle test using the TGAI is required for diazinon because the end-use product is expected to be transported to water from the intended use site and the EEC is equal to or greater than one-tenth of the NOAEL in the fish early life-stage or invertebrate life-cycle test. The preferred test species is fathead minnow. The guideline (72-5) for this study has not been fulfilled.

(iii) Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity test using the TGAI is required to establish the toxicity of diazinon to aquatic invertebrates. The preferred test organism is Daphnia magna, but early instar amphipods, stoneflies, mayflies, or midges may also be used. Results of this test are tabulated below. The toxicity value (EC_{50}) appearing in the shaded area of the table will be used to calculate the acute risk quotients (RQ's) in subsequent sections.

Table 50: Freshwater Invertebrate Acute Toxicity - Diazinon Technical and End-Use Formulations

Species/Static or Flow-through	% ai	LC_{50}/ EC_{50} (ppb)/(C.I.)	Toxicity Category	MRID/Accession (AC) No. Author/Year	Study Classification[1]
		Technical			

Table 50: Freshwater Invertebrate Acute Toxicity - Diazinon Technical and End-Use Formulations

Daphnid *(Simocephalus sp.)*/not reported	89.0	1.4/ (1.2-1.6)	very highly toxic	40094602/Johnson, W. & M. Finley/1980	Supplemental
Daphnid *(Daphnia pulex)*/not reported	89.0	0.8/ (0.6-1.1)	very highly toxic	40094602/Johnson, W. & M. Finley/1980	Supplemental
Daphnid *(Daphnia magna)*not reported	>89.0	0.83/ (0.83-1.10) NOEC= 0.56	very highly toxic	00109022/AC228039/ Vilkas, A./1976	Core
Mosquito Larvae *(Culex pipiens fatigans)*/not reported	not reported	35.0/ (not reported)	very highly toxic	05000811/Rogsriyam, Y., et.al./1968	Supplemental
Scud *(Gammarus fasciatus)*/not reported	89.0	0.20 (0.15-0.28)	very highly toxic	40094602/Johnson, W. & M. Finley/1980	Supplemental
Stonefly *(Pteronarcys sp.)*/not reported	89.0	25 (20-30)	very highly toxic	40094602/Johnson, W. & M. Finley/1980	Supplemental
End-Use Formulations					
Daphnid *(Daphnia magna)*/static	48.0	1.1/ (1.0-1.3) NOEC= < 0.89	very highly toxic	40509803/Suprenant, D./1987	Core
Daphnid *(Daphnia magna)*/static	23.0	0.522/ (0.459-0.585)	very highly toxic	00121283/AC248821/ Morrissey, A.E./1978	Core

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline).

Since the LC_{50}/EC_{50} falls in the range of 0.20 to 35.0 ppb, diazinon is categorized very highly toxic to freshwater aquatic invertebrates on an acute basis. The supplemental studies were not conducted according to acceptable protocols: the information was provided as a reference source with no supporting data or statistical analysis; the test species was not a preferred test species; and/or temperature, dissolved oxygen level, pH, hardness of water and percent of the active ingredient in the test substance were not provided. The guideline (72-2a) is fulfilled (MRIDs 00109022, 40509803 and 00121283).

iv. Freshwater Invertebrate, Chronic

A freshwater aquatic invertebrate life-cycle test using the TGAI is required for diazinon since the end-use product is expected to be transported to water from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent, (2) any aquatic acute LC_{50} or EC_{50} is less than 1.0 ppm, and (3) the EEC in water is equal to or greater than 0.01 of any acute EC50 or LC50 value. The preferred test species is *Daphnia magna*. Results of this test are tabulated below. The toxicity value (NOEC) appearing in the shaded area of the table will be used to calculate the chronic risk quotients (RQ's) in subsequent sections.

Table 51: Freshwater Aquatic Invertebrate Life-Cycle Toxicity

Species/Static Renewal or Flow-through	% ai	21-day NOEC/LOEC (ppb)	Endpoints Affected	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Daphnid *(Daphnia magna*/ flow-through	87.7	0.17/< 0.32	mortality of all test organisms at two highest concentrations (0.32 & 0.83 ppb)	40782302/Suprenant, D./1988	Supplemental

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline)

The supplemental study was not conducted according to acceptable protocols: statistical analyses on survival and length of test organism could not be verified due to the lack of raw data. This study is repairable to a core study provided the missing raw data is submitted for statistical verification. The guideline (72-4b) is not fulfilled.

c. Toxicity to Estuarine and Marine Animals

i. Estuarine and Marine Animals, Acute

Acute toxicity testing with estuarine and marine fish using the TGAI is required for diazinon because the end-use product is expected to reach the marine/estuarine environment because of its use in coastal counties. The preferred test organisms are the sheepshead minnow. Results of these tests are tabulated in Table below. The toxicity value (LC_{50}) appearing in the shaded area of the table will be used to calculate the acute risk quotients (RQ's) in subsequent sections.

Table 52: Estuarine/Marine Fish Acute Toxicity

Species/Static or Flow-through	% ai	LC_{50}/EC_{50} (ppb)	Toxicity Category	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Sheepshead Minnow *(Cyprinodon variegatus)*/flow-through	>89.0	LC_{50}=1470.0 NOEC= <160	moderately toxic	RO0DO008/ Goodman, L. et.al./1979	Core
Sheepshead Minnow *(Cyprinodon variegatus)*/not reported	95.1	1,500.0[a]	moderately toxic	40228401/Mayer F./1986	Supplemental
Striped mullet *(Mugil cephalus)*/not reported	95.1	150.0[a]	highly toxic	40228401/Mayer F./1986	Supplemental

[a] DER not found. Information came from Eco-Tox One-Liner

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline)

Since the LC_{50} ranges from 150-to-1,500 ppb, diazinon is categorized as highly to moderately toxic to estuarine/marine fish on an acute basis. The guideline (72-3a) is fulfilled (AC 40228401 and RO0DO008).

ii. Estuarine and Marine Fish, Chronic

An estuarine/marine fish early life-stage toxicity test using the TGAI is required for diazinon because the end-use product is expected to be transported to the estuarine/marine environment from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent, (2) any aquatic acute LC_{50} or EC_{50} is less than 1.0 ppm, and (3) the EEC in water is equal to or greater than 0.01 of any acute LC_{50} or EC_{50} value. The preferred test species is sheepshead minnow. Results of this test are tabulated below. The toxicity value (NOEC) appearing in the shaded area of the table will be used to calculate the chronic risk quotients (RQ's) in subsequent sections.

Table 53: Estuarine/Marine Fish Early Life-Stage Toxicity Under Flow-through Conditions

Species/ Study Duration	% ai	NOEC/LOEC (ppb)	Endpoints Affected	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Sheepshead Minnow *(Cyprinodon variegatus)*/4 weeks	>89.0	0.39/0.56 (calculated)	impaired reproduction during exposure and 3 to 4 weeks after exposure	RO0DO008/ Goodman, L. et.al./1979	Core
Sheepshead Minnow	87.3%	4.3 / 8.0	Growth (length, weight)	442448-02/ J. V. Sousa 1997	Core

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline)

The guideline (72-4a) is fulfilled (AC# RO0DO008 ; MRID 442448-02). Estimates of chronic toxicity for estuarine/marine fish ranged from 0.39 to 4.3 : g/L.

An estuarine/marine fish life-cycle test using the TGAI is required for diazinon because the end-use product is expected to be transport to water from the intended use site, and the following condition is met: (1) the EEC is equal to or greater than one-tenth of the NOAEC in the fish early life-stage or invertebrate life-cycle test. The preferred test species is sheepshead minnow. The guideline (72-5) for this study has not been fulfilled.

iii. Estuarine and Marine Invertebrates, Acute

Acute toxicity testing with estuarine/marine invertebrates using the TGAI is required for diazinon because the end-use product is expected to reach the marine/estuarine environment because of it use in coastal counties. The preferred test species are mysid shrimp and eastern oyster. Results of these tests are tabulated below. The toxicity value (EC_{50}) appearing in the shaded area of the table will be used to calculate the acute risk quotients (RQ's) in subsequent sections.

Table 54: Estuarine/Marine Invertebrate Acute Toxicity - Diazinon Technical

Species/Static or Flow-through	% ai.	96-hour LC50/EC50 (ppb) (measured/nominal)	Toxicity Category	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Brown shrimp *(Penaeus aztecus)*/not reported	95.1	28.0[a]	very highly toxic	40228401/not reported/1986	Supplemental
Eastern oyster (shell deposition or embryo-larvae) *(Crassostrea virginica)*/not reported	95.1	>1000.0[a]	moderately toxic	40228401/not reported/1986	Supplemental
Eastern oyster (shell deposition or embryo-larvae) *(Crassostrea virginica)*/flow-through	87.7	EC_{50}=880.0 NOAEC=210.0	highly toxic	40625502/ Surprenant, D./1988	Core
Grass shrimp *(Palaemonetes kadiakensis)*/not reported	95.1	28.0[a]	very highly toxic	40228401/not reported/1986	Supplemental
Mysid *(Americamysis bahia)*/flow-through	87.7	EC_{50}=4.2 NOAEC=<2.7	very highly toxic	40625501/ Surprenant, D./1988	Core

[a] DER not found. Information came from Eco-Tox One-Liner

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline)

Since the LC_{50}/EC_{50} falls in the range of 4.2 to >1000.0 ppb, diazinon is categorized as very highly to moderately toxic to estuarine/marine invertebrates on an acute basis. The guideline (72-3b and 72-3c) is fulfilled (MRIDs 40625502 and 40625501).

iv. Estuarine and Marine Invertebrate, Chronic

An estuarine/marine invertebrate life-cycle toxicity test using the TGAI is required for diazinon because the end-use product is expected to be transported to the estuarine/marine environment from the intended use site and (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent, (2) any aquatic acute LC_{50} or EC_{50} is less than 1.0 ppm, and (3) the EEC in water is equal to or greater than 0.01 of any acute LC_{50} or EC_{50} value. The preferred test species is mysid shrimp. The guideline (72-4) requirement is fulfilled.(MRID 44244801).

Table 55: Estuarine/Marine Invertebrate Life Cycle Toxicity Under Flow-through Conditions

Species/ Study Duration	% ai	NOEC/LOEC (ppb)	Endpoints Affected	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Myisid Shrimp *(Mysidopsis bahia)*/4 weeks	87.3	0.23 / 0.42 (calculated)	growth (weight)	442448-01 J. V. Sousa. 1997	Core

v. Estuarine and Marine Field Studies

No studies were submitted and no studies are required.

d. Toxicity to Plants

i. Terrestrial

Terrestrial plant testing (seedling emergence and vegetative vigor) is required for herbicides that have terrestrial non-residential outdoor use patterns and that may move off the application site through volatilization (vapor pressure >1.0 x 10^{-5}mm Hg at 25ºC) or drift (aerial or irrigation) and/or that may have endangered or threatened plant species associated with the application site.

Currently, terrestrial plant testing is not required for pesticides other than herbicides except on a case-by-case basis (*e.g.*, labeling bears phytotoxicity warnings incident data or literature that demonstrate phytotoxicity).

For seedling emergence and vegetative vigor testing the following plant species and groups should be tested: (1) six species of at least four dicotyledonous families, one species of which is soybean (*Glycine max*) and the second is a root crop, and (2) four species of at least two monocotyledonous families, one of which is corn (*Zea mays*).

Tier I tests measure the response of plants, relative to a control, at a test level that is equal to the highest use rate (expressed as lbs ai/A). Results of Tier 1 toxicity testing on the technical/TEP material are discussed below. The Data Evaluation Records (DERs) cannot be located and the results come from the 1988 Diazinon Registration Standard (as amended in August 1989) and cannot be fully tabulated.

Tier I studies for diazinon were conducted to determine the effects on seedling emergence for soybean, lettuce, carrot, tomato, cucumber, cabbage, oat, ryegrass, corn, and onion at an equivalent application rate of 10 lb ai/A. At this rate, there was a 26% decrease in radicle length, for oat, a 27% decrease for tomato, and a 43% decrease in carrot. For Tier I seedling emergence, carrot is the most sensitive dicot and oat is the most sensitive monocot. The guideline (122-1a) is fulfilled (MRID 40509805).

Tier I studies for diazinon were also conducted to determine the effects on vegetation vigor, as measured in plant height, for soybean, lettuce, carrot, tomato, cucumber, cabbage, oat, and ryegrass. At the maximum application rate of 10 lb ai/A, diazinon had a 25% or greater detrimental effect on onion cucumber, and tomato. The guideline (122-1b) is fulfilled (MRID 40509804).

Terrestrial Tier II plant testing was required for diazinon because a greater than 25% detrimental effect level on radical length was observed in oat, carrot and tomato in the Tier I seedling emergence study resulting in a requirement for Tier II testing in tomato, carrot, and oat. A 25% or greater detrimental effect on vegetative vigor, as measured in plant height, was observed on onion, cucumber and tomato in the Tier I vegetative vigor study which resulted in Tier II testing in tomato, onion, lettuce, cucumber, and carrot.

Tier II tests measure the response of plants, relative to a control, and five or more test concentrations. Results of Tier II toxicity testing on the technical/TEP material are tabulated below. The toxicity values appearing in the shaded area of the table will be used to calculate the acute risk quotients (RQ's) in subsequent sections.

Table 56: Nontarget Terrestrial Plant Seedling Emergence Toxicity (Tier II)

Species	% ai	EC25/EC05 (lbs ai/A) Endpoint Affected	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Monocot- Oat *(Avena sativa)*	87.7	5.26/0.17 shoot height	40803001/Pan-Agricultural Labs/1988	Core
Dicot- Root Crop- Carrot *(Daucus carota)*	87.7	9.03/1.58 shoot height	40803001/Pan-Agricultural Labs/1988	Core
Dicot- Tomato *(Lycopersicon esculentum)*	87.7	22.1/2.31 shoot height	40803001/ Pan-Agricultural Labs /1988	Core

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline)

For Tier II seedling emergence carrot is the most sensitive dicot (EC_{25} = 9.03 lb ai/A) and oat is the most sensitive monocot (EC_{25} = 5.26 lb ai/A). The guideline (123-1a) is fulfilled (MRID # 40803001).

Table 57: Nontarget Terrestrial Plant Vegetative Vigor Toxicity (Tier II)

Species	% ai	EC25/EC05 (lbs ai/A) Endpoint Affected	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Monocot- Onion *(Allium cepa)*	87.7	>7.0/7.0 shoot height	40803002/Pan-Agricultural Labs/1988	Core
Dicot- Lettuce *(Lactuca sativa)*	87.7	>7.0/7.0 shoot height & dry weight	40803002/Pan-Agricultural Labs/1988	Core
Dicot- Carrot *(Daucus carota)*	87.7	>7.0/7.0 shoot height & dry weight	40803002/Pan-Agricultural Labs/1988	Core
Dicot- Tomato *(Lycopersicon esculentum)*	87.7	>7.0/7.0 shoot height & dry weight	40803002/Pan-Agricultural Labs/1988	Core
Dicot- Cucumber *(Cucumis sativus)*	87.7	3.23/1.27 shoot height	40803002/Pan-Agricultural Labs/1988	Core
Dicot- Cucumber *(Cucumis sativus)*	87.7	4.81/2.32 dry weight	40803002/Pan-Agricultural Labs/1988	Core

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline)

For Tier II vegetative vigor cucumber is the most sensitive dicot (EC_{25} = 3.23 lb ai/A) and onion is the most sensitive monocot (EC_{25} = >7.0 lb ai/A). The guideline (123-1b) is fulfilled (MRID # 40803002).

ii. Aquatic Plants

Currently, aquatic plant testing is not required for pesticides other than herbicides and fungicides except on a case-by-case basis (*e.g.*, labeling bears phytotoxicity warnings incident data or literature that demonstrate phytotoxicity). Aquatic plant testing is required for diazinon because of its terrestrial outdoor use pattern; its ability to move offsite in both surface and ground water; and its demonstrated phytotoxicity as determined in the terrestrial plant testing. Results of Tier II which satisfies Tier I toxicity testing (for the tested species, *Selenastrum capricornutum*) on the technical/TEP material are tabulated below. The toxicity value (EC_{50}) appearing in the shaded area of the table will be used to calculate the acute risk quotients (RQ's) in subsequent sections.

Table 58: Nontarget Aquatic Plant Toxicity (Tier II)

Species	% ai	EC50/ EC05 (ppm)	MRID/Accession (AC) No. Author/Year	Study Classification[1]
Nonvascular Plants				
Green algae *(Selenastrum capricornutum)*	87.7	3.7/<0.06	40509806/Hughes, J./not reported (1988 review date)	Core

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline)

Both Tier I and Tier II guidelines (122-2 and 123-2) are fulfilled for the nonvascular plant test species, *Selenastrum capricornutum* (MRID 40509806). The Tier I guideline (122-2) is not fulfilled for the test species, *Lemna gibba* (duckweed).

e. Summary of Public Literature for Ecological Laboratory and Field Studies

Numerous laboratory studies conducted with diazinon have been reported in the open literature. The results of several of these studies confirming the acute and chronic toxicity of diazinon to a wide variety of aquatic organisms are summarized in the table below. The studies are tabulated with the fish studies discussed first, then aquatic invertebrates and finally algae and bacterial studies.

Table 59: Public Literature Data Summary, Laboratory Toxicity Studies

Study Type	Test Material and Organism	Test Concentration	Affected Endpoint	Citation
Intestinal tissue histology	Diazinon Snakefish (*Channa punctatus*)	1 day exposure at 0.37 ppm, 4 day exposure at 0.28 ppm, 14 day exposure at 0.15 ppm	Slight vacuolation and cytoplasmic granulation of the lamina propria (intestinal cells). Cytoplasmic vacuolation and granular inclusion of the mucosa and submucosa. Loss of structural integrity of the mucosal folds. Degenerative musculature and submucosal necrosis	Anees, date unknown
Acute and chronic toxicity	Diazinon (92.6% purity) Sheepshead minnows (*Cyprinodon variegatus*)	Acute test: 180, 320, 560, 1000, and 1800 :g/L Chronic test: 0.63, 1.25, 2.5, 5.0, and 10.0 :g/L	Acute test: 96-hour LC_{50} of 1,470 :g/L. Chronic test: NOAECwas <0.47 :g/L as a result of significant reductions in the number of eggs produced per day. Impaired reproduction was also observed at least 3 to 4 weeks after fish were placed in clean water, even when their AchE activity was normal and they contained no detectable residues.	Goodman *et al.*, 1979
Brain cholinesterase inhibition study	Diazinon Sheepshead minnows (*Cyprinodon variegatus*)	Concentration that killed from 40 to 70 percent of the fish in 24 and 48 hours.	The number of fish killed was proportional to the inhibition of cholinesterase in sheepshead minnow brains. However, the "threshold level" that would cause mortality was not determined as a result of the limitations of the photometric assay method for detecting cholinesterase inhibition.	Coppage, 1970
Brain AChE inhibition	Diazinon Sheepshead minnows (*Cyprinodon variegatus*)	Concentrations that killed from 40 to 60% of the fish in 2, 24, 48, and 72 hours.	Brain AChE activity was reduced to below 17.7% of normal in sheepshead minnows exposed to a concentration of diazinon that would kill 40 to 60% of the test fish.	Coppage, 1972

Table 56: Public Literature Data Summary, Laboratory Toxicity Studies continued

Study Type	Test Material and Organism	Test Concentration	Affected Endpoint	Citation
Lethal body burden study	Diazinon technical (99% purity) Guppy (*Poecilia reticulata*)	High concentration (50 mg/L mean measured) was chosen that would ensure mortality within 24 hours. The low concentration (10 mg/L mean measured) was chosen so that the fish would survive for 4-12 days.	Fish exposed to the high concentration of diazinon dies within 24 hours and had lethal body burdens (LBB) of 8.0 :mols/g wet weight. Fish at the low concentration died between 1 and 3 days and had the same LBB (8.0 :mols/g wet weight) as the high concentration. Time to death was dependent on the aqueous concentration of diazinon while the LBB was not.	Ohayo-Mitoko and Deneer, 1993
in vitro liver metabolism	Diazinon-^{14}C and diazoxon hepatic subcellular preparations from channel catfish (*Ictalurus punctatus*)	Not reported	The microsomal fraction is more active than the soluble fraction in the *in vitro* metabolism of diazinon. The metabolism of diazinon by this particular enzyme system (i.e., P_{450} mixed function oxidase system) requires both NADPH and oxygen.	Hogan, 1972
Brain AChE inhibition	Commercial grade diazinon (25% purity) Largemouth bass (*Micropterus salmoides*)	Fish were exposed to 90, 180, 270, 360, and 450 :g/L of diazinon for 24 hours under static conditions	No mortalities at any concentration. AChE activity was significantly reduced at all concentrations (48.2 -91.4% inhibition)	Pan and Dutta, 1998
Bioconcentration study	Diazinon Topmouth gudgeon (*Pseudorasbora parva*)	Concentrations from 5 to 20 ppb.	With a water solubility of 40.5 ppm and a partition coefficient (octanol/water) of 1,386, the bioconcentration factor of diazinon in topmouth gudgeon was 152.	Kanazawa, 1980
Acute toxicity	Diazinon Mysids (*Mysidopsis bahia*) and post larval pink shrimp (*Penaeus duorarum*)	Exposure concentrations not reported. Exposed 96 hours.	Mysids are approximately 2.5 times more sensitive to diazinon than post-larval pink shrimp. 96-hour LC_{50} (:g/L): Mysids: 8.5 (8.2 -8.9) Pink shrimp: 21 (19-24)	Cripe, 1994
Acute Behavior Toxicity	60% purity commercial grade diazinon Shrimp (genus unspecified)	Shrimp exposed to 0.1 of 1.0 ppb ai for 24 hours. After transfer back to clean water, behavioral responses monitored	Grasping a source (pipette) of amino acids was the endpoint. Shrimp exposed to both concentrations of diazinon demonstrated a significant reduction in grasping as well as three other responses (for shrimp exposed to 0.1 ppb ai)	Chu and Lau, 1994

Study Type	Test Material and Organism	Test Concentration	Affected Endpoint	Citation
Acute toxicity	Three species of green algae and one species of blue-green algae were tested individually, A mixed culture was also exposed to diazinon.	Exposure concentrations range from 1 to 40 ppm of formulated material. Exposure period was either 9 or 10 days.	Two individual-tested algae unaffected by exposure, other two affected at highest two concentrations (i.e., NOAEC= 10 ppm and LOEC = 20 ppm). Diversity of mixed inoculum decreased at highest three concentrations (i.e., NOAEC= 5 ppm and LOEC = 10 ppm).	Doggett and Rhodes, 1991

ENVIRONMENTAL RISK ASSESSMENT

1. Risk Presumptions and Levels of Concern

Risk characterization integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. The means of this integration is called the quotient method. Risk quotients (RQs) are calculated by dividing exposure estimates by acute and chronic ecotoxicity values.

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are used by OPP to analyze potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) **acute high** -- potential for acute risk is high; regulatory action may be warranted in addition to restricted use classification, (2) **acute restricted use** -- the potential for acute risk is high, but may be mitigated through restricted use classification, (3) **acute endangered species** - endangered species may be adversely affected, and (4) **chronic risk** - the potential for chronic risk is high regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to birds or mammals.

The ecotoxicity test values (measurement endpoints) used in the acute and chronic risk quotients are derived from required studies. Examples of ecotoxicity values derived from short-term laboratory studies that assess acute effects are: (1) LC_{50} (fish and birds), (2) LD_{50} (birds and mammals), (3) EC_{50} (aquatic plants and aquatic invertebrates) and (4) EC_{25} (terrestrial plants). Examples of toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are: (1) LOEL (birds, fish, and aquatic invertebrates) and (2) NOAEL (birds, fish and aquatic invertebrates). For birds, mammals, fish and aquatic invertebrates the NOAEL generally is used as the ecotoxicity test value in assessing chronic effects, although other values may be used when justified. Risk presumptions and the corresponding RQs and LOCs, are tabulated below.

Table 60: Risk Presumptions for Terrestrial Animals

Risk Presumption	RQ	LOC
Birds		
Acute High Risk	EEC[1]/LC50 or LD50/sqft[2] or LD50/day[3]	0.5
Acute Restricted Use	EEC/LC50 or LD50/sqft or LD50/day (or LD50 < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC50 or LD50/sqft or LD50/day	0.1
Chronic Risk	EEC/NOAEL	1
Wild Mammals		
Acute High Risk	EEC/LC50 or LD50/sqft or LD50/day	0.5
Acute Restricted Use	EEC/LC50 or LD50/sqft or LD50/day (or LD50 < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC50 or LD50/sqft or LD50/day	0.1
Chronic Risk	EEC/NOAEL	1

[1] abbreviation for Estimated Environmental Concentration (ppm) on avian/mammalian food items

[2] mg/ft² / LD50 * wt. of bird

[3] mg of toxicant consumed/day / LD50 * wt. of bird

Table 61: Risk Presumptions for Aquatic Animals

Risk Presumption	RQ	LOC
Acute High Risk	EEC[1]/LC50 or EC50	0.5
Acute Restricted Use	EEC/LC50 or EC50	0.1
Acute Endangered Species	EEC/LC50 or EC50	0.05
Chronic Risk	EEC or NOAEL	1

[1] EEC = (ppm or ppb) in water

Table 62: Risk Presumptions for Plants

Risk Presumption	RQ	LOC
Terrestrial and Semi-Aquatic Plants		
Acute High Risk	EEC[1]/EC25	1
Acute Endangered Species	EEC/EC05 or NOAEL	1
	Aquatic Plants	
Acute High Risk	EEC[2]/EC50	1
Acute Endangered Species	EEC/EC05 or NOAEL	1

[1] EEC = lbs ai/A

[2] EEC = (ppb/ppm) in water

a. Risk Quotients for Nontarget Terrestial Animals

The acute risk quotients for single broadcast applications of nongranular products are tabulated below.

Table 63

Avian Acute and Chronic Risk Quotients for Single Broadcast Application of Nongranular Diazinon Products based on a mallard duck (Anas platyrhynchos) LC50 of 32 ppm and a NOAECof 8.3 ppm.

Site/App. Method	App. Rate (lbs ai/A)	Food Items	Maximum EEC (ppm)	Acute RQ (EEC/ LC50)[a]	Chronic RQ (EEC/NOAEC)[b]
Corn	10.00	Short grass	2400.00	75.00	289.16
ground & aerial		Tall grass	1100.00	34.38	132.53
		Broadleaf plants/Insects	1350.00	42.19	162.65
		Seeds	150.00	4.69	18.07
Cotton, Forage Crops (1), Sorghum, Soybean,	4.00	Short grass	960.00	30.00	115.66
Sugarcane and Tobacco		Tall grass	440.00	13.75	53.01
ground & aerial		Broadleaf plants/Insects	540.00	16.88	65.06
		Seeds	60.00	1.88	7.23
Ginseng/	0.50	Short grass	120.00	3.75	14.46
ground		Tall grass	55.00	1.72	6.63
		Broadleaf plants/Insects	67.50	2.11	8.13
		Seeds	7.50	0.23	0.90
Vegetable Crops (2)	4.00	Short grass	960.00	30.00	115.66
ground & aerial		Tall grass	440.00	13.75	53.01
		Broadleaf plants/Insects	540.00	16.88	65.06
		Seeds	60.00	1.88	7.23
Vegetable Crops (3)	10.00	Short grass	2400.00	75.00	289.16
ground & aerial		Tall grass	1100.00	34.38	132.53
		Broadleaf plants/Insects	1350.00	42.19	162.65
		Seeds	150.00	4.69	18.07

(1) Cowpea, Clover and Lespedeza.

(2) Typical Rates on the following crops: Beans (succulent), Beets (Table), Broccoli, Brussels Sprouts, Cabbage, Carrots, Cauliflower, Collards, Cucumber, Endive, Kale, Lettuce (Head & Table), Melons (Cantaloupes, Casabas, Crenshaws, Honeydews, Muskmelons, Persians, and hybrids of these and Watermelon) Mustard, Parsley, Parsnips, Peppers, Potatoes, Radishes, Rutabagas, Spinach, Squash (Summer & Winter), Sweet Corn, Sweet Potatoes, Swiss Chard, Tomatoes, Turnips (roots & tops) & Sugar Beets

(3) Maximum rates on the following crops: Bean, Beet, Broccoli, Brussels Sprouts, Cabbage, Carrot, Cauliflower, Celery, Collard, Cucumber, Endive, Kale, Lettuce, Melon, Mustard, Onion, Peas, Potato, Radish, Sweet Corn, Sweet Potato and Tomato

a RQ $ 0.5 exceeds acute high, acute restricted and acute endangered species LOCs.
RQ $ 0.2 exceeds acute restricted and acute endangered species LOCs.
RQ $ 0.1 exceeds acute endangered species LOCs.
b RQ $ 1.0 exceeds chronic LOC.

Analysis of the results indicate that for single applications of diazinon nongranular products avian high acute, chronic, restricted use, and endangered species levels of concern (LOC's) are exceeded at the maximum application rates for all the use patterns evaluated.

The acute and chronic risk quotients for multiple broadcast applications of nongranular products are tabulated below.

Table 64

Avian Acute and Chronic Risk Quotients for Multiple Broadcast Applications (ground and/or aerial) of Nongranular Products for Diazinon based on a Mallard duck LC_{50} of 32 ppm and a NOAEC of 8.3 ppm considering a diazinon foliar dissipation half-life of 5.3 days.

Site/App. Method	App. Rate (lbs ai/A)/No. of Apps/interval	Food Items	Maximum EEC (ppm)	Acute RQ (EEC/ LC50)[a]	Chronic RQ (EEC/NOEC)[b]
Almonds, Walnuts,	3/3	Short grass	853.88	26.68	102.88
Pecans	14- day interval	Tall grass	391.36	12.23	47.15
		Broadleaf plants/Insects	480.31	15.01	57.87
		Seeds	53.37	1.67	6.43
Pome and Stone Fruits	2/3	Short grass	749.08	23.41	90.25
	7-day interval	Tall grass	343.33	10.73	41.37
		Broadleaf plants/Insects	421.36	13.17	50.77
		Seeds	46.82	1.46	5.64
Banana (HI, only)	0.5/3 (A)	Short grass	187.27	5.85	22.56
	7-day interval	Tall grass	85.83	2.68	10.34
		Broadleaf plants/Insects	105.34	3.29	12.69
		Seeds	11.70	0.37	1.41
Berries (1)	2/5	Short grass	571.55	17.86	68.86
	14-day interval	Tall grass	261.96	8.19	31.56
		Broadleaf plants/Insects	321.94	10.05	38.73
		Seeds	35.72	1.12	4.30
Cranberries	3/4	Short grass	856.84	26.78	103.24
	14-day interval	Tall grass	392.72	12.27	47.32
		Broadleaf plants/Insects	481.97	15.06	58.07
		Seeds	53.55	1.67	6.45
Grapes	1/5	Short grass	396.10	12.38	47.72
	7 day interval	Tall grass	181.55	5.67	21.87
		Broadleaf plants/Insects	222.81	6.96	26.84
		Seeds	24.76	0.77	2.98
Pineapple	2/8	Short grass	492.65	15.40	59.36
	28 day interval	Tall grass	225.80	7.06	27.20
		Broadleaf plants/Insects	277.12	8.66	33.39
		Seeds	30.79	0.96	3.71
Strawberries & Hops	1/4	Short grass	389.94	12.19	46.98

Table 64

Avian Acute and Chronic Risk Quotients for Multiple Broadcast Applications (ground and/or aerial) of Nongranular Products for Diazinon based on a Mallard duck LC_{50} of 32 ppm and a NOAEC of 8.3 ppm considering a diazinon foliar dissipation half-life of 5.3 days.

Site/App. Method	App. Rate (lbs ai/A)/No. of Apps/interval	Food Items	Maximum EEC (ppm)	Acute RQ (EEC/ LC50)[a]	Chronic RQ (EEC/NOEC)[b]
	7- day interval	Tall grass	178.72	5.59	21.53
		Broadleaf plants/Insects	219.34	6.85	26.43
		Seeds	24.37	0.76	2.94
Lawns	4/3 (A)	Short grass	1498.16	46.82	180.50
	7-day interval	Tall grass	686.66	21.46	82.73
		Broadleaf plants/Insects	842.72	26.33	101.53
		Seeds	93.64	2.93	11.28

(1) Blackberry, Blueberry, Boysenberry, Dewberry, Loganberry, & Raspberry

(A) Three applications used in table but label indicates; "Repeat as necessary."

a RQ $ 0.5 exceeds acute high, acute restricted and acute endangered species LOCs.
RQ $ 0.2 exceeds acute restricted and acute endangered species LOCs.
RQ $ 0.1 exceeds acute endangered species LOCs.
b RQ $ 1.0 exceeds chronic LOC.

Analysis of the results indicate that for multiple applications of diazinon nongranular products avian high acute, chronic, restricted use, and endangered species levels of concern are exceeded at maximum application rates for all use patterns.

Birds may be exposed to granular pesticides ingesting granules when foraging for food or grit. They also may be exposed by other routes, such as by walking on exposed granules or drinking water contaminated by granules. The number of lethal doses (LD50s) that are available within one square foot immediately after application (LD50s/sq.ft) is used as the risk quotient for granular/bait products. Risk quotients are calculated for three separate weight class of birds: 1000 g (*e.g.*, waterfowl), 180 g (*e.g.*, upland gamebird), and 20 g (*e.g.*, songbird).

The acute risk quotients for broadcast applications of granular products are tabulated below.

Table 65

Avian Risk Quotients for Diazinon Granular Products (Broadcast) Based on a Mallard Duck (Anas platyrhynchos) LD50 of 1.44 mg/kg.

Site/Application Method	/Rate in lbs ai/A	% (decimal) of Pesticide Left on the Surface	Body Weight (g)	Acute RQ[1,2] (LD50/sq.ft)
Alfalfa Clover Mixture/Unincorporated				
Apple/Unincorporated (a)	4.00	1.00	20	1446.25

Table 65
Avian Risk Quotients for Diazinon Granular Products (Broadcast) Based on a Mallard Duck (Anas platyrhynchos) LD50 of 1.44 mg/kg.

Site/Application Method	/Rate in lbs ai/A	% (decimal) of Pesticide Left on the Surface	Body Weight (g)	Acute RQ[1,2] (LD50/sq.ft)
			180	160.69
			1000	28.93
Corn/Unincorporated	10.00	1.00	20	3615.62
			180	401.74
			1000	72.31
Cranberry/Unincorporated (b)	3.00	1.00	20	1084.69
			180	120.52
			1000	21.69
Mustard/Incorporated (A)	1	0.15	20	54.23
			180	6.03
			1000	1.08
Mustard (B), Sorghum, Soybeans, Strawberries	4	0.15	20	216.94
			180	24.10
			1000	4.34
Potato/Unincorporated	6.00	1.00	20	2169.37
			180	241.04
			1000	43.39
Sweet potato/Incorporated (A)	3	0.15	20	162.70
			180	18.08
			1000	3.25
Vegetable Crops /Incorporated(d)(A)	4	0.15	20	216.94
			180	24.10
			1000	4.34

Table 65

Avian Risk Quotients for Diazinon Granular Products (Broadcast) Based on a Mallard Duck (Anas platyrhynchos) LD50 of 1.44 mg/kg.

Site/Application Method	/Rate in lbs ai/A	% (decimal) of Pesticide Left on the Surface	Body Weight (g)	Acute RQ[1,2] (LD50/sq.ft)
Vegetable Crops /Incorporated(e)(B)	10.00	0.15	20	542.34
			180	60.26
			1000	10.85
Nonagricultural Uncultivated Areas/Unincorporated	6.00	1.00	20	2169.37
			180	241.04
			1000	43.39
Ornamental Herbaceous Plants, Woody Shrubs & Vines, and/or Shade Trees and Pastures/ Unincorporated(a)	6.00	1.00	20	2169.37
			180	241.04
			1000	43.39
Ornamental Lawns & Turf /Unincorporated(a)				
6.5	6.50	1.00	20	2350.15
			180	261.13
			1000	47.00
Household/Domestic Dwellings Outdoor Premises/Unincorporated (f)	5.00	1.00	20	1807.81
			180	200.87
			1000	36.16

1 RQ = App. Rate (lbs ai/A) * % (decimal) of Pesticide Left on the Surface * (453,590 mg/Lbs / 43,560 sq.ft/A) / LD50 mg/kg * Weight of Animal (g) / 1000 g/kg

2 RQ $ 0.5 exceeds acute high, acute restricted and acute endangered species LOCs.
RQ $ 0.2 exceeds acute restricted and acute endangered species LOCs.
RQ $ 0.1 exceeds acute endangered species LOCs.

(a) Based on a single application whereas the use pattern allows three applications per crop cycle.

(b) Use pattern due to SLN(s). Labels allow up to 2 applications/crop cycle.

(c) Beans (succulent) (lima, pole, snap), Beets, Broccoli, Brussels Sprouts, Cabbage, Carrot, Cauliflower, Celery, Chard (Swiss), Collards, Corn (Sweet), Cucumber, Endive (Escarole), Ginseng, Kale, Lettuce, Melons (Cantaloupe, Honeydew, Musk, Water, & Winter), Onion, Parsley, Peas (succulent), Peppers, Potato (White/Irish), Radish, Rutabaga, Spinach, Squash (Summer & Winter), Sugar Beets, Tomato, & Turnip.

(d) Bean, Beet, Cabbage, Carrot, Chard (Swiss), Lettuce, Melon (Casaba, Cantaloupe,Crenshaw, Honeydew, Persian, & Water), Onion, Parsley, Peas, Radish, Tomato, Turnip,

(e) Label indicates to repeat applications when needed. Rate is given for a single application.

(A) Typical rates of application for use pattern.

(B) Maximum rates of application for use pattern.

Analysis of the results indicate that for single applications of diazinon granular products avian high acute, restricted use, and endangered species levels of concern are exceeded at maximum application rates for all use patterns evaluated.

The acute risk quotients for diazinon applications of treated seed are tabulated below.

Table 66

Avian Acute Risk Quotients for Single Diazinon Applications of Treated Seed Based on a Mallard Duck LD50 of 1.44 mg ai/kg.

Site/Method Band Width (feet)	lb. ai/1000 ft of Row	Bird Body Weight (g)	% (decimal) of Pesticide Left on the Surface	Exposed[1] (mg/sq.ft)	LD50 (mg/kg)	Acute RQ[2,a] (LD50/sq.ft)
Corn (a)/In-furrow-Incorporated						
0.08	0.0007	20	0.01	0.04	1.44	1.38
		180		0.04		0.15
		1000		0.04		0.03
Peas (b) & Beans (c) (succulent) /In-furrow-Incorporated						
0.08	0.0008	20	0.01	0.05	1.44	1.57
		180		0.05		0.17
		1000		0.05		0.03

1 Exposed = App. Rate (lbs.ai/1000 ft of row)* 453,590 mg/lbs * % (decimal) Unincorporated / bandwidth (ft) * 1000 ft

2 RQ = Exposed (mg/sq.ft.)/[LD50(mg/kg) * (Weight of the Animal (g)/1000 (g/kg))]

(a) Based on 11 lbs. corn seed planted per acre and one bushel of shelled corn equaling 56 lbs. Assumes 20 in. row spacing. Seed treated at 3 oz. of product (50% ai, WP) per bushel of seed.

(b) Based on 80 lbs. pea seed planted per acre and one bushel of shelled peas equaling 60 lbs. Assumes 20 in. row spacing. Seed treated at 0.5 oz.of product (50% ai, WP) per bushel of seed.

(c) Based on 73 lbs. bean seed planted per acre and one bushel of shelled beans equaling 56 lbs. Assumes 20 in. row spacing. Seed treated at 0.5 oz. of product (50% ai,WP) per bushel of seed.

a RQ $ 0.5 exceeds acute high, acute restricted and acute endangered species LOCs.
RQ $ 0.2 exceeds acute restricted and acute endangered species LOCs.
RQ $ 0.1 exceeds acute endangered species LOCs.

Analysis of the results indicate that for single applications of diazinon used as a seed treatment, avian high acute, restricted use, and endangered species levels of concern are exceeded for all use patterns.
In addition to the above evaluation of seed treatments based on risk quotients, it is useful to consider a direct comparison of the amount of diazinon on treated seeds and the amount found in/on diazinon granules. For example, at an application rate of 1.8 oz. of a 15% ai product per 50 lbs. seed and approximately 1,350 corn seeds/lb (McArdle, 1989), there would be 0.113 mg diazinon/seed if the diazinon were applied uniformly to all seeds. In comparison, Balcomb et al., (1984) found that diazinon 14G granules (approximately 14% ai) weigh 0.331 mg on average, and thus each granule contains

approximately 0.046 mg diazinon on average. Hence, the residue on a treated seed is approximately 2.5 times the amount of diazinon found in a typical 14G granule.

Thus, the amount of diazinon on a single corn seed could easily kill a small bird. For example, in Balcomb's work, one diazinon 14G granule per bird killed 40%, and five killed 80%, of the house sparrows tested. Five granules/bird killed 100% of the redwinged blackbirds tested. Since the residue on the corn seed is approximately 2.5% greater, it would take 2.5X fewer seeds than granules to kill a bird. If diazinon is not applied uniformly to seeds (e.g., due to imprecise manual mixing), some will contain even more than 0.113 mg diazinon, presenting an even greater hazard.

Seeds are reportedly planted 1" to 2" below the ground surface with up to 24,000 planted/acre (McArdle, 1989). Many birds can easily probe to this depth in search of food. Given the attractiveness of seeds to birds and the lethal amounts of diazinon found on even a single seed, a substantial risk to birds is present.

The acute risk quotients for banded applications of granular products are tabulated below.

Table 67
Avian Acute Risk Quotients for Granular Diazinon Products (Banded or In-furrow) Based On a Mallard Duck (Anas platyrhynchos) LD50 of 1.44 mg/kg.

Site/Method Band Width (feet)	lb. ai/1000 ft of Row	Bird Body Weight (g)	% (decimal) of Pesticide Left on the Surface	Exposed[1] (mg/sq.ft)	LD50 (mg/kg)	Acute RQ[2,a] (LD50/sq.ft)
Bean/Banded-Unincorporated (A)						
0.5	0.08	20	1.00	72.57	1.44	2,519.94
		180		72.57		279.99
		1000		72.57		50.40
Sorghum; Soybeans Banded-Unincorporated (B)						
0.5	0.15	20	1.00	136.08	1.44	4,724.90
		180		136.08		524.99
		1000		136.08		94.50

1 Exposed = App. Rate (lbs.ai/1000 ft of row)* 453,590 mg/lbs * % (decimal) Unincorporated / bandwidth (ft) * 1000 ft

2 RQ = Exposed (mg/sq.ft.)/[LD50(mg/kg) * Weight of the Animal (g)/1000 (g/kg)]

(A) Rate of application is 2 lb ai/A. Assumes 20 in. row spacing.

(B) Rate of application is 4 lb ai/A. Assumes 20 in. row spacing.

a RQ $ 0.5 exceeds acute high, acute restricted and acute endangered species LOCs.
RQ $ 0.2 exceeds acute restricted and acute endangered species LOCs.
RQ $ 0.1 exceeds acute endangered species LOCs.

Analysis of the results indicate that for banded applications of diazinon granular products, avian high acute, restricted use, and endangered species levels of concern are exceeded at maximum application rates for the all use patterns.

b. Mammals

Estimating the potential for adverse effects to wild mammals is based on EEB's draft 1995 SOP of mammalian risk assessments and methods used by Hoerger and Kenaga (1972) as modified by Fletcher *et al*. (1994). The concentration of diazinon in the diet that is expected to be acutely lethal to 50% of the test population (LC50) is determined by dividing the LD50 value (usually rat LD50) by the % (decimal of) body weight consumed. A risk quotient is then determined by dividing the EEC by the derived LC50 value. Risk quotients are calculated for three separate weight classes of mammals (15, 35, and 1000 g), each presumed to consume four different kinds of food (grass, forage, insects, and seeds). The acute risk quotients for broadcast applications of nongranular products are tabulated below.

The mammalian acute risk quotients for single applications of nongranular diazinon products are tabulated in the next two tables.

Table 68

Mammalian (Herbivore/Insectivore) Acute Risk Quotients for Single Application of Nongranular Diazinon Products (Broadcast) Based on a laboratory rat (Rattus norvegicus) LD50 of 505 mg/kg.

Site/Application Method/	Rate in lbs ai/A	Body Weight Body (g)	% Body Weight Consumed	EEC (ppm) ShortGrass	EEC (ppm) Forage & Small Insects	EEC (ppm) Large Insects	Acute RQ [a,b] Short Grass	Acute RQ [a,b] Forage & Small Insects	Acute RQ [a,b] Large Insects
Corn	10	15	95	2400	1350	150	4.51	2.54	0.282
ground & aerial		35	66	2400	1350	150	3.14	1.76	0.196
		1000	15	2400	1350	150	0.71	0.40	0.045
Cotton, Forage Crops (1)	4	15	95	960	540	60	1.81	1.02	0.113
Sorghum, Soybeans, Sugarcane, Tbbacco		35	66	960	540	60	1.25	0.71	0.078
ground & aerial		1000	15	960	540	60	0.29	0.16	0.018
Ginseng	0.5	15	95	120	67.5	7.5	0.23	0.13	0.014
ground		35	66	120	67.5	7.5	0.16	0.09	0.010
		1000	15	120	67.5	7.5	0.04	0.02	0.002

Site/Application Method/	Rate in lbs ai/A	Body Weight Body (g)	% Body Weight Consumed	EEC (ppm) ShortGrass	EEC (ppm) Forage & Small Insects	EEC (ppm) Large Insects	Acute RQ [a,b] Short Grass	Acute RQ [a,b] Forage & Small Insects	Acute RQ [a,b] Large Insects
Vegetable Crops (2)	4	15	95	960	540	60	1.81	1.02	0.113
ground & aerial		35	66	960	540	60	1.25	0.71	0.078
		1000	15	960	540	60	0.29	0.16	0.018
Vegetable Crops (3)	10	15	95	2400	1350	150	4.51	2.54	0.282
ground & aerial		35	66	2400	1350	150	3.14	1.76	0.196
		1000	15	2400	1350	150	0.71	0.40	0.045

a RQ = EEC (ppm)/[LD50 (mg/kg)/ %(decimal) Body Weight Consumed]

b RQ $ 0.5 exceeds acute high, acute restricted and acute endangered species LOCs.

RQ $ 0.2 exceeds acute restricted and acute endangered species LOCs.

RQ $ 0.1 exceeds acute endangered species LOCs.

1 Cowpea, Clover and Lespedeza.

2 Typical Rates on the following crops: Beans (succulent), Beets (Table), Broccoli, Brussels Sprouts, Cabbage, Carrots, Cauliflower, Collards, Cucumber, Endive, Kale, Lettuce (Head & Table), Melons (Cantaloupes, Casabas, Crenshaws, Honeydews, Muskmelons, Persians, and hybrids of these and Watermelon) Mustard, Parsley, Parsnip, Peppers, Potatoes, Radishes, Rutabagas, Spinach, Squash (Summer & Winter), Sweet Corn, Sweet Potatoes, Swiss Chard, Tomatoes, Turnips (roots & tops) & Sugar Beets

3 Maximum rates on the following crops: Bean, Beet, Broccoli, Brussels Sprouts, Cabbage, Carrot, Cauliflower, Celery, Collard, Cucumber, Endive, Kale, Lettuce, Melon, Mustard, Onion, Peas, Potato, Radish, Sweet Corn, Sweet Potato and Tomato

Analysis of the results indicate that for single applications of diazinon nongranular products, the mammalian (herbivore/insectivore) high acute risk level of concern is exceeded for all uses evaluated except ginseng. Mammalian acute restricted use and endangered species risk levels of concern are exceeded for all evaluated uses.

Table 69

Mammalian (Granivore) Acute Risk Quotients for Single Application of Nongranular Diazinon Products (Broadcast) Based on a laboratory rat (Rattus norvegicus) LD50 of 505 mg/kg.

Site/Application Method/	Rate in lbs ai/A	Body Weight Body (g)	% Body Weight Consumed	EEC (ppm) Seeds	Acute RQ Seeds [a,b]
Corn	10	15	21	150	0.0624
ground & aerial		35	15	150	0.0446
		1000	3	150	0.0089
Cotton, Forage Crops (1)	4	15	21	60	0.0250
Sorghum, Soybeans, Sugarcane, Tbbacco		35	15	60	0.0178
ground & aerial		1000	3	60	0.0036
Ginseng	0.5	21	7.5	7.5	0.0031
ground		35	15	7.5	0.0022
		1000	3	7.5	0.0004

Table 69

Mammalian (Granivore) Acute Risk Quotients for Single Application of Nongranular Diazinon Products (Broadcast) Based on a laboratory rat (Rattus norvegicus) LD50 of 505 mg/kg.

Site/Application Method/	Rate in lbs ai/A	Body Weight Body (g)	% Body Weight Consumed	EEC (ppm) Seeds	Acute RQ Seeds [a,b]
Vegetable Crops (2)	4	15	21	60	0.0250
ground & aerial		35	15	60	0.0178
		1000	3	60	0.0036
Vegetable Crops (3)	10	15	21	150	0.0624
ground & aerial		35	15	150	0.0446
		1000	3	150	0.0089

a RQ = EEC (ppm)/[LD50 (mg/kg)/ %(decimal) Body Weight Consumed]

b RQ $ 0.5 exceeds acute high, acute restricted and acute endangered species LOCs.

RQ $ 0.2 exceeds acute restricted and acute endangered species LOCs.

RQ $ 0.1 exceeds acute endangered species LOCs.

1 Cowpea, Clover and Lespedeza.

2 Typical Rates on the following crops: Beans (succulent), Beets (Table), Broccoli, Brussels Sprouts, Cabbage, Carrots, Cauliflower, Collards, Cucumber, Endive, Kale, Lettuce (Head & Table), Melons (Cantaloupes, Casabas, Crenshaws, Honeydews, Muskmelons, Persians, and hybrids of these and Watermelon) Mustard, Parsley, Parsnip, Peppers, Potatoes, Radishes, Rutabagas, Spinach, Squash (Summer & Winter), Sweet Corn, Sweet Potatoes, Swiss Chard, Tomatoes, Turnips (roots & tops) & Sugar Beets

3 Maximum rates on the following crops: Bean, Beet, Broccoli, Brussels Sprouts, Cabbage, Carrot, Cauliflower, Celery, Collard, Cucumber, Endive, Kale, Lettuce, Melon, Mustard, Onion, Peas, Potato, Radish, Sweet Corn, Sweet Potato and Tomato

An analysis of the results indicate that for single applications of diazinon nongranular products, no mammalian (grainivore) levels of concern are exceeded for the evaluated uses.

The mammalian acute risk quotients for multiple applications of nongranular diazinon products are tabulated in the next two tables.

Table 70

Mammalian (Herbivore/Insectivore) Acute Risk Quotients for Multiple Applications of Nongranular Diazinon Products (Broadcast; ground and aerial) Based on a laboratory rat (Rattus norvegicus) LD50 of 505 mg/kg considering a diazinon foliar dissipation half-life of 5.3 days..

Site/Application Method/	Rate in lbs ai/A and # appl	Body Weight (g)	% Body Weight Consumed	EEC (ppm) ShortGrass	EEC (ppm) Forage & Small Insects	EEC (ppm) Large Insects	Acute RQ Short Grass [a,b]	Acute RQ Forage & Small Insects [a,b]	Acute RQ Large Insects [a,b]
Almonds, Walnuts,	3 3	15	95	853.88	480.31	53.37	1.61	0.99	0.10
Pecans	14-day			853.88					
	interval	35	66		480.31	53.37	1.12	0.63	0.07
		1000	15	853.88	480.31	53.37	0.25	0.14	0.02

Table 70

Mammalian (Herbivore/Insectivore) Acute Risk Quotients for Multiple Applications of Nongranular Diazinon Products (Broadcast; ground and aerial) Based on a laboratory rat (Rattus norvegicus) LD50 of 505 mg/kg considering a diazinon foliar dissipation half-life of 5.3 days..

Site/Application Method/	Rate in lbs ai/A and # appl	Body Weight (g)	% Body Weight Consumed	EEC (ppm) ShortGrass	EEC (ppm) Forage & Small Insects	EEC (ppm) Large Insects	Acute RQ Short Grass [a,b]	Acute RQ Forage & Small Insects [a,b]	Acute RQ Large Insects [a,b]
Pome and Stone Fruits	2 3	15	95	749.08	421.36	46.82	1.51	0.79	0.09
	7-day interval	35	66	749.08	421.36	46.82	0.98	0.55	0.06
		1000	15	749.08	421.36	46.82	0.22	0.13	0.01
Banana (HI, only)	0.5 3(A)	15	95	187.27	105.34	11.7	0.35	0.20	0.02
	7-day interval	35	66	187.27	105.34	11.7	0.24	0.14	0.02
		1000	15	187.27	105.34	11.7	0.06	0.03	0.00
Berries (1)	2 5	15	95	571.55	321.49	35.72	1.08	0.60	0.07
	14-day interval	35	66	571.55	321.49	35.72	0.75	0.42	0.05
		1000	15	571.55	321.49	35.72	0.17	0.10	0.01
Cranberries	3 4	15	95	856.84	481.97	53.55	1.61	0.91	0.10
	14-day interval	35	66	856.84	481.97	53.55	1.12	0.63	0.07
		1000	15	856.84	481.97	53.55	0.25	0.14	0.02
Grapes	1 5	15	95	396.1	221.81	24.76	0.75	0.42	0.05
	7-day interval	35	66	396.1	221.81	24.76	0.52	0.29	0.03
		1000	15	396.1	221.81	24.76	0.12	0.07	0.01
Pineapple	2 8	15	95	492.65	277.12	30.79	0.93	0.52	0.06
	28-day interval	35	66	492.65	277.12	30.79	0.64	0.36	0.04
		1000	15	492.65	277.12	30.79	0.15	0.08	0.01
Strawberries and Hops	1 4	15	95	389.84	219.34	24.37	0.73	0.41	0.05
	7-day interval	35	66	389.84	219.34	24.37	0.51	0.29	0.03
		1000	15	389.84	219.34	24.37	0.12	0.07	0.01
Lawns	4 3(A)	15	95	1498.16	842.72	93.64	2.82	1.59	0.18
	7-day interval	35	66	1498.16	842.72	93.64	1.96	1.10	0.12
		1000	15	1498.16	842.72	93.64	0.44	0.25	0.03

a RQ = EEC (ppm)/[LD50 (mg/kg)/ %(decimal) Body Weight Consumed]

b RQ $ 0.5 exceeds acute high, acute restricted and acute endangered species LOCs.

RQ $ 0.2 exceeds acute restricted and acute endangered species LOCs.

RQ $ 0.1 exceeds acute endangered species LOCs.

(1) Blackberry, Blueberry, Boysenberry, Dewberry, Loganberry, & Raspberry

(A) Three applications used in table but label indicates; "Repeat as necessary."

Analysis of the results indicate that for multiple applications of diazinon nongranular products, the mammalian(herbivore/insectivore) high acute, restricted use and endangered species risk levels of concern are exceeded for all uses evaluated.

Table 71

Mammalian (Granivore) Acute Risk Quotients for Multiple Application of Nongranular Diazinon Products (Broadcast; ground and aerial) Based on a laboratory rat (Rattus norvegicus) LD50 of 505 mg/kg considering a diazinon foliar dissipation half-life of 5.3 days.

Site/Application Method/ Rate	App. Rate (lbs ai/A)/No. of Apps.	Body Weight (g)	% Body Weight Consumed	EEC (ppm) Seeds	Acute RQ Seeds [a,b]
Almonds, Walnuts,	3 3	15	21	53.37	0.020
Pecans	14-day interval	35	15	53.37	0.020
		1000	3	53.37	0.003
Pome and Stone Fruits	2 3	15	21	46.82	0.020
	7-day interval	35	15	46.82	0.010
		1000	3	46.82	0.003
Banana (HI, only)	0.5 3(A)	15	21	11.7	0.005
	7-day interval	35	15	11.7	0.003
		1000	3	11.7	0.001
Berries (1)	2 5	15	21	35.72	0.010
	14-day interval	35	15	35.72	0.010
		1000	3	35.72	0.002
Cranberries	3 4	15	21	53.55	0.020
	14-day interval	35	15	53.55	0.020
		1000	3	53.55	0.003
Grapes	1 5	15	21	24.76	0.010
	7-day interval	35	15	24.76	0.010
		1000	3	24.76	0.001

Table 71

Mammalian (Granivore) Acute Risk Quotients for Multiple Application of Nongranular Diazinon Products (Broadcast; ground and aerial) Based on a laboratory rat (Rattus norvegicus) LD50 of 505 mg/kg considering a diazinon foliar dissipation half-life of 5.3 days.

Site/Application Method/ Rate	App. Rate (lbs ai/A)/No. of Apps.	Body Weight (g)	% Body Weight Consumed	EEC (ppm) Seeds	Acute RQ Seeds [a,b]
Pineapple	2 8	15	21	30.79	0.010
	28 day interval	35	15	30.79	0.010
		1000	3	30.79	0.002
Strawberries & Hops	1 4	15	21	24.37	0.010
	7-day interval	35	15	24.37	0.010
		1000	3	24.37	0.001
Lawns	4 3	15	21	93.64	0.040
	7-day interval	35	15	93.64	0.030
		1000	3	93.64	0.010

a RQ = EEC (ppm)/[LD50 (mg/kg)/ %(decimal) Body Weight Consumed]

b RQ $ 0.5 exceeds acute high, acute restricted and acute endangered species LOCs.

RQ $ 0.2 exceeds acute restricted and acute endangered species LOCs.

RQ $ 0.1 exceeds acute endangered species LOCs.

(1) Blackberry, Blueberry, Boysenberry, Dewberry, Loganberry, & Raspberry

(A) Three applications used in table but label indicates; "Repeat as necessary."

(B) Three applications used in table but label indicates; "Repeat as necessary." Rate based on 100 gal/A finished spray.

An analysis of the results indicate that for multiple applications of diazinon nongranular products, the mammalian (grainivore) no levels of concern are exceeded for the considered uses.

The chronic risk quotients for multiple broadcast applications of nongranular products are tabulated below.

Table 72

Mammalian Chronic Risk Quotients for Multiple Applications of Diazinon Nongranular Products (Broadcast; ground and aerial) Using on a NOAEL of 10 ppm Based on 2-Generation Reproductive Study on laboratory rats (Rattus norvegicus) considering a diazinon foliar dissipation half-life of 5.3 days..

Site	App. Rate (lbs ai/A)/No. of Apps.	Food Items	Maximum EEC (ppm)	Chronic RQ (Max. EEC/NOAEL)[a]
Almond, Pecans and Walnuts	3/3	Short grass	853.88	85.39
	14-day interval	Tall grass	391.36	39.14

Table 72

Mammalian Chronic Risk Quotients for Multiple Applications of Diazinon Nongranular Products (Broadcast; ground and aerial) Using on a NOAEL of 10 ppm Based on 2-Generation Reproductive Study on laboratory rats (Rattus norvegicus) considering a diazinon foliar dissipation half-life of 5.3 days..

Site	App. Rate (lbs ai/A)/No. of Apps.	Food Items	Maximum EEC (ppm)	Chronic RQ (Max. EEC/NOAEL)[a]
		Broadleaf plants/Insects	480.31	48.03
		Seeds	53.37	5.34
Pome and Stone Fruits	2/3	Short grass	749.08	74.91
	7-day interval	Tall grass	343.33	34.33
		Broadleaf plants/Insects	421.36	42.14
		Seeds	46.82	4.68
Banana (HI, only)	0.5/3 (A)	Short grass	187.27	18.73
	7-day interval	Tall grass	85.83	8.58
		Broadleaf plants/Insects	105.34	10.53
		Seeds	11.70	1.17
Berries (1)	2/5	Short grass	571.55	57.15
	14-day interval	Tall grass	261.96	26.2
		Broadleaf plants/Insects	321.49	32.15
		Seeds	35.72	3.57
Cranberries	3/4	Short grass	856.84	85.68
	14-day interval	Tall grass	392.72	39.27
		Broadleaf plants/Insects	481.97	48.2
		Seeds	53.55	5.36
Grapes	1/5	Short grass	396.10	39.61
	7-day interval	Tall grass	181.55	18.15
		Broadleaf plants/Insects	222.81	22.28
		Seeds	24.76	2.48
Pineapple	2/8	Short grass	492.65	44.27
	28-day interval	Tall grass	225.80	22.58
		Broadleaf plants/Insects	277.12	27.71
		Seeds	30.79	3.08
Strawberries & Hops	1/4	Short grass	389.94	38.99
	7-day interval	Tall grass	178.72	17.87
		Broadleaf plants/Insects	219.34	21.93
		Seeds	24.37	2.44

Table 72

Mammalian Chronic Risk Quotients for Multiple Applications of Diazinon Nongranular Products (Broadcast; ground and aerial) Using on a NOAEL of 10 ppm Based on 2-Generation Reproductive Study on laboratory rats (Rattus norvegicus) considering a diazinon foliar dissipation half-life of 5.3 days..

Site	App. Rate (lbs ai/A)/No. of Apps.	Food Items	Maximum EEC (ppm)	Chronic RQ (Max. EEC/NOAEL)[a]
Lawns	4/3 (A)	Short grass	1498.16	149.82
	7-day interval	Tall grass	686.66	68.67
		Broadleaf plants/Insects	842.72	84.27
		Seeds	93.64	9.36

a RQ $ 1.0 exceeds chronic LOC.

(1) Blackberry, Blueberry, Boysenberry, Dewberry, Loganberry, & Raspberry

(A) Three applications used in table but label indicates; "Repeat as necessary."

(B) Three applications used in table but label indicates; "Repeat as necessary." Rate based on 100 gal/A finished spray.

Analysis of the results indicate that for multiple applications of diazinon nongranular products, mammalian chronic levels of concern are exceeded for all mammals at all application sites evaluated for maximum expected concentrations in food items.

Mammalian species also may be exposed to granular/bait pesticides by ingesting granules. They also may be exposed by other routes, such as by walking on exposed granules and drinking water contaminated by granules. The number of lethal doses (LD50's) that are available within one square foot immediately after application can be used as a risk quotient (LD50's/sq.ft) for the various types of exposure to bait pesticides. Risk quotients are calculated for three separate weight classes of mammals: 15 g, 35 g, and 1000 g.

The acute risk quotients for broadcast applications of granular products are tabulated below.

Table 73

Mammalian Acute Risk Quotients for Granular Diazinon Products (Broadcast) Based on a laboratory rat (*Rattus norvegicus*) LD50 of 505 mg/kg.

Site/Application Method/Rate in lbs ai/A	% (decimal) of Pesticide Left on the Surface	Body Weight (g)	LD50 (mg/kg)	Acute RQ (LD50/sq.ft)[1,2]
Alfalfa Clover Mixture/Unincorporated				
4	1.00	15	505	5.499
		35		2.357
		1000		0.082
Apple/Unincorporated (a)				
4	1.00	15	505	5.499
		35		2.357
		1000		0.082
Corn/Unincorporated				
10	1.00	15	505	13.747
		35		5.891

Table 73

Mammalian Acute Risk Quotients for Granular Diazinon Products (Broadcast) Based on a laboratory rat (*Rattus norvegicus*) LD50 of 505 mg/kg.

Site/Application Method/Rate in lbs ai/A	% (decimal) of Pesticide Left on the Surface	Body Weight (g)	LD50 (mg/kg)	Acute RQ (LD50/sq.ft)[1,2]
		1000		0.206
Cranberry/Unincorporated (b)				
3	1.00	15	505	4.124
		35		1.767
		1000		0.062
Mustard/Incorporated (A)				
1	0.15	15	505	0.206
		35		0.088
		1000		0.003
Mustard/Incorporated (B)				
4	0.15	15	505	0.825
		35		0.353
		1000		0.012
Potato/Unincorporated				
6	1.00	15	505	8.248
		35		3.535
		1000		0.124
Sorghum/Incorporated				
4	0.15	15	505	0.825
		35		0.353
		1000		0.012
Soybean/Incorporated				
4	0.15	15	505	0.825
		35		0.353
		1000		0.012
Strawberry/Incorporated				
4	0.15	15	505	0.825
		35		0.353
		1000		0.012
Sugarcane/Unincorporated				
6	1.00	15	505	8.248
		35		3.535
		1000		0.124
Sweet potato/Incorporated (A)				
3	0.15	15	505	0.619
		35		0.265
		1000		0.009
Vegetable Crops /Incorporated(d) (A)				
4	0.15	15	505	0.825
		35		0.353
		1000		0.012
Vegetable Crops /Incorporated(e) (B)				

Table 73

Mammalian Acute Risk Quotients for Granular Diazinon Products (Broadcast) Based on a laboratory rat (*Rattus norvegicus*) LD50 of 505 mg/kg.

Site/Application Method/Rate in lbs ai/A	% (decimal) of Pesticide Left on the Surface	Body Weight (g)	LD50 (mg/kg)	Acute RQ (LD50/sq.ft)[1,2]
10	0.15	15	505	2.062
		35		0.884
		1000		0.031
Nonagricultural Uncultivated Areas/Unincorporated				
6	1.00	15	505	8.248
		35		3.535
		1000		0.124
Ornamental Herbaceous Plants, Woody Shrubs & Vines, and/or Shade Trees /Unincorporated(a)				
6	1.00	15	505	8.248
		35		3.535
		1000		0.124
Ornamental Lawns & Turf /Unincorporated(a)				
6.5	1.00	15	505	8.935
		35		3.829
		1000		0.134
Pastures/Unincorporated (a)				
6	1.00	15	505	8.248
		35		3.535
		1000		0.124
Household/Domestic Dwellings Outdoor Premises/Unincorporated (f)				
5	1.00	15	505	6.873
		35		2.946
		1000		0.103

1 RQ = App. Rate (lbs ai/A) * % (decimal) of Pesticide Left on the Surface * (453,590 mg/Lbs / 43,560 ft2/A) / LD50 mg/kg * Weight of Animal (g) / 1000 g/kg

2 RQ $ 0.5 exceeds acute high risk, acute restricted use and acute endangered species LOCs.

RQ $ 0.2 exceeds acute restricted use and acute endangered species LOCs.

RQ $ 0.1 exceeds acute endangered species LOCs.

(a) Based on a single application whereas the use pattern allows three applications per crop cycle.

(b) Use pattern due to SLN(s). Labels allow up to 2 applications/crop cycle.

(c) Beans (succulent) (lima, pole, snap), Beets, Broccoli, Brussels Sprouts, Cabbage, Carrot, Cauliflower, Celery, Chard (Swiss), Collards, Corn (Sweet), Cucumber, Endive (Escarole), Ginseng, Kale, Lettuce, Melons (Cantaloupe, Honeydew, Musk, Water, & Winter), Onion, Parsley, Peas (succulent), Peppers, Potato (White/Irish), Radish, Rutabaga, Spinach, Squash (Summer & Winter), Sugar Beets, Tomato, & Turnip.

(d) Bean, Beet, Cabbage, Carrot, Chard (Swiss), Lettuce, Melon (Casaba, Cantaloupe, Crenshaw, Honeydew, Persian, & Water), Onion, Parsley, Peas, Radish, Tomato, Turnip,

(e) Label indicates to repeat applications when needed. Rate is given for a single application.

(A) Typical rates of application for use pattern.

(B) Maximum rates of application for use pattern.

An analysis of the results indicate that for broadcast applications of diazinon granular products, mammalian acute high risk, restricted use, and endangered species levels of concern are exceeded for all use sites evaluated. Currently, EFED does not have a standard procedure for assessing chronic risk to mammalian species for granular products.

The acute risk quotients for banded applications of granular products are tabulated below.

Table 74

Mammalian Acute Risk Quotients for Granular Diazinon Products (Banded) Based on a laboratory rat (*Rattus norvegicus*) LD50 of 505 mg/kg

Site/Method Band Width (feet)	lb. ai/1000 ft of Row	Bird Body Weight (g)	% (decimal) of Pesticide Left on the Surface	Exposed[1] (mg/sq.ft)	LD50 (mg/kg)	Acute RQ[2,3] (LD50/sq.ft)
Bean/Banded-Unincorporated (A)						
0.5	0.08	15	1.00	72.57	505	9.58
		35		72.57		4.11
		1000		72.57		0.14
Sorghum/Banded-Unincorporated (B)						
0.5	0.15	15	1.00	136.08	505	17.96
		35		136.08		7.70
		1000		136.08		0.27
Soybean/Banded-Unincorporated (B)						
0.5	0.15	15	1.00	136.08	505	17.96
		35		136.08		7.70
		1000		136.08		0.27

1 Exposed = App. Rate (lbs.ai/1000 ft of row)* 453,590 mg/lbs * % (decimal) Unincorporated / bandwidth (ft) * 1000 ft

2 RQ = Exposed (mg/sq.ft.)/LD50(mg/kg) * Weight of the Animal (g)/1000 (g/kg)

3 RQ $ 0.5 exceeds acute high risk, acute restricted use and acute endangered species LOCs.

RQ $ 0.2 exceeds acute restricted use and acute endangered species LOCs.

RQ $ 0.1 exceeds acute endangered species LOCs.

(A) Rate of application is 2 lb ai/A. Assumes 20 in. row spacing.

(B) Rate of application is 4 lb ai/A. Assumes 20 in. row spacing.

An analysis of the results indicate that for banded applications of diazinon granular products, mammalian acute high risk, restricted use, and endangered species levels of concern are exceeded at registered maximum application rates for all sites reviewed.

4. Insects

Currently, EFED does not assess risk to nontarget insects. Results of acceptable studies are used for recommending appropriate label precautions.

5. Risk Quotients for Nontarget Freshwater Aquatic Animals

For a Tier I assessment, EFED calculates EECs using the GENeric Expected Environmental Concentration Program (GENEEC). The EECs are used for assessing acute and chronic risks to aquatic organisms. The GENEEC program uses basic environmental fate data and pesticide label information to estimate the EECs in a one-hectare, two-meter deep pond following the treatment of a 10-hectare field. The runoff event occurs two days after the last application. The model takes into account adsorption to the soil or sediment, incorporation of the pesticide, degradation in soil before runoff, and degradation within the water body. The model also accounts for direct deposition of off-target spray drift onto the water body (assuming 5% of the application rate for aerial applications and 1% for ground applications). It was anticipated that Risk Quotients (RQs) calculated using the GENEEC EECs would exceed the LOCs for diazinon. When LOC's are exceeded by GENEEC estimates, a second level of screening using the Pesticide Root Zone Model version 3.1 (PRZM) (Carsel et al, 1997) and EXAMS 2.97.5 (Exposure Analysis Modeling System) (Burns, 1997) is used. The aquatic EECs (Tier II assessment) for diazinon, with the exception of the modeling scenarios used for pineapple and lawns, are estimated using PRZM/EXAMS. The GENEEC model was used for pineapple and lawns because EFED currently does not have a PRZM/EXAMS modeling scenario for these use sites. Please refer to the **Modeling** section in the **Water Resource Assessment** for additional background information and the input parameters used in this modeling scenario.

The PRZM/EXAM modeling tools used by EFED are designed to be conservative tools; 90% of simulated sites are expected to have environmental concentrations which are lower than the Tier II estimates. EFED uses environmental fate and transport computer models to calculate refined EECs. PRZM simulates pesticide surface water runoff on daily time steps, incorporating runoff, infiltration, erosion, and evaporation. The model calculates foliar dissipation and runoff, pesticide uptake by plants, soil microbial transformation, volatilization, and soil dispersion and retardation. EXAMS simulates pesticide fate and transport in an aquatic environment (one hectare body of water, two meters deep with no outflow). The EECs have been calculated so that in any given year, there is a 10% probability that the maximum average concentration of that duration in that year will equal or exceed the EEC at the site.
The Tier II model uses a single site which represents a high exposure scenario for the use of the pesticide on a particular crop use site. The weather and agricultural practice are simulated at the site over multiple years so that the probability of an EEC occurring at that site can be estimated. Sites were chosen for refined EEC's because they are major crops grown in areas where both freshwater and estuarine/marine organisms may be exposed to a pesticide through spray drift or runoff or a combination of both.

Acute risk assessments are performed using peak EEC values for single and multiple applications. Chronic risk assessments are performed using the 21-day EECs for invertebrates and 60-day EECs (56-day EECs for pineapple and lawns due to the use of the GENEEC model) for fish. The Tier II EECs are listed below.

Table 75. Estimated Environmental Concentrations (EECs) for Aquatic Exposure using PRZM/EXAMS modeling. Values are the upper tenth percentile in $\mu g\ L^{-1}$ (ppb).

Location/Crop/application method/rate/# apps	PEAK (ACUTE)	4 DAY	21 DAY	60 DAY	90 DAY	YEARLY AVERAGE (CHRONIC)
CA Almonds aerial 3/1	8.89	8.33	7.94	6.39	5.74	1.61
CA Walnuts aerial 3/3	21.5	20.7	18.3	16.2	14.5	5.76
FL Citrus aerial 10/2	386	365	312	209	160	48.8
FL Cucumbers broadcast 4/1	429	414	356	258	205	58.7
FL Strawberries aerial 1/4	112	109	98.8	83.0	74.8	25.0
GA Sweet Corn aerial 1.25/5	71.1	68.1	57.3	39.0	33.8	11.6
GA Peaches aerial 2/3	41.5	40.1	35.2	27.1	22.3	6.61
HI Pineapple[1] aerial 4/1	91.2	89.4	80.5	67.2	NA[2]	NA[2]
LA Sugarcane aerial 4/1	73.4	70.9	62.9	53.1	50.5	13.2
ME Potatoes broadcast 4/1	72.7	68.7	58.9	45.7	37.0	11.6
MI Blueberries aerial 1/5	37.7	36.2	32.8	22.4	19.0	6.47
MS Cotton aerial 1/3	40.3	38.1	33.8	26.9	23.1	8.21
MS Soybeans aerial 4/1	38.8	37.1	31.2	24.5	20.2	7.15
NC Tobacco aerial 3/1	47.0	45.2	38.9	31.7	25.4	7.05
NY Apples aerial 2/3	25.1	23.8	20.5	15.4	12.8	4.60
NY Grapes aerial 1/5	10.7	10.2	9.10	7.97	7.37	3.33
OH Corn aerial 9.8/1	64.9	62.8	55.2	40.9	34.6	11.2
OR Alfalfa aerial 1.5/3	11.8	11.3	9.78	7.46	6.03	1.81
TX Sorghum broadcast 4/1	28.8	27.6	23.5	18.8	15.6	5.39
Lawns[1] 4/3	182.3	178.1	157.8	129.0	NA[2]	NA

[1] Modeled using GENEEC.

[2] Not applicable.

Linear adjustments to the rates of application were made to the EECs used in the following aquatic risk tables from the EECs modeled in Table 72, above, to account for the higher application rates currently registered for diazinon. For example, the peak EEC value, 37.7 ppb for blueberries, modeled at a maximum of 1 lb ai/A for five applications one time per year was adjusted to 75.4 ppb (2 times the modeled value) to account for the higher application rate (2 lb ai/A, 5 times per year) registered for diazinon. The sites affected by these adjustments were: berries (blueberries), corn, cotton, potato, sugarcane and tobacco. The modeled values were based on a limited diazinon labeling review to determine the maximum application rates and number of applications per crop cycle or year. Some labels indicate that almonds, cucumbers, and pineapple may receive more applications than our modeling estimates; these additional applications were not considered during this review.

I. Freshwater Fish. Acute and chronic risk quotients for freshwater fish are tabulated below.

Table 76 Diazinon Risk Quotients for Freshwater Fish Based On a rainbow trout (*Salmo gairdneri*) LC50 of 90 ppb and a brook trout (*Salvelinus fontinalis*) NOEC of < 0.55 ppb.

Site/Application Method	Rate in lbs ai per A/No. of Apps.	EEC Peak (ppb)	EEC 60-Day Ave. (ppb)	Acute RQ (Peak EEC/LC50)[a]	Chronic RQ (60-Day EEC/NOEC)[b,c]
Alfalfa aerial	1.5 3	11.80	7.46	0.13	13.56
almond aerial	3 1	8.89	6.39	0.10	11.61
Apples and Pears Aerial	2 3	25.10	15.40	0.28	28.00
Berries (1) Aerial	2 5	75.40	44.80	0.84	81.45
Citrus aerial	10 2	386.00	209.00	4.29	380.00
Corn aerial	10 1	66.22	41.73	0.74	75.87
Cotton aerial	4 1	53.73	35.87	0.60	65.22
Cucumber broadcast	4 1	429.00	258.00	4.76	469.09
Lawns broadcast	4 3	182.30	129.00	2.03	234.55
Grape aerial	1 5	10.70	7.97	0.12	14.49
Pineapple ground	4 1	91.20	67.20	1.01	122.18
Potato broadcast	10 1	181.75	114.25	2.02	207.73
Sorghum broadcast	4 1	28.80	18.80	0.32	34.18
Soybean aerial	4 1	38.80	24.50	0.43	44.55
Strawberry aerial	1 4	112.00	83.00	1.24	150.91
Stone Fruits (2) aerial	2 3	25.10	15.40	0.28	28.00
Sugarcane aerial	6 1	110.10	79.65	1.22	144.82

Table 76 Diazinon Risk Quotients for Freshwater Fish Based On a rainbow trout (*Salmo gairdneri*) LC50 of 90 ppb and a brook trout (*Salvelinus fontinalis*) NOEC of < 0.55 ppb.

Site/Application Method	Rate in lbs ai per A/No. of Apps.	EEC Peak (ppb)	EEC 60-Day Ave. (ppb)	Acute RQ (Peak EEC/LC50)[a]	Chronic RQ (60-Day EEC/NOEC)[b,c]
Sweet corn aerial	1.25 5	71.10	39.00	0.79	70.91
Tobacco aerial	4 1	62.67	42.27	0.70	76.85
Walnut aerial	3 3	21.50	16.20	0.24	29.45

(1) Blackberry, Blueberry, Boysenberry, Dewberry, Loganberry, & Raspberry

(2) Apricot, Cherry, Nectarine, Peach, Plum and Prune

a RQ $ 0.5 exceeds acute high risk, acute restricted use and acute endangered species LOCs.
RQ $ 0.1 exceeds acute restricted use and acute endangered species risk LOCs.
RQ $ 0.05 exceeds acute endangered species risk LOC.

b RQ $ 1.00 exceeds chronic risk LOC.

c Actual RQs are greater than the values shown, since the NOEC is less than the value used in the denominator.

The results indicate that, for freshwater fish, aquatic acute high risk levels of concern are exceeded for all use sites except alfalfa, almond, apple, pear, grape, sorghum, soybean and walnut. The acute restricted use risk, acute endangered species risk, and chronic levels of concern are exceeded for all use sites.

II. Freshwater Invertebrates. The acute and chronic risk quotients for freshwater invertebrates are tabulated below.

Table 77: Diazinon Risk Quotients for Freshwater Invertebrates Based On a scud (*Gammarus fasciatus*) LC50 of 0.2 ppb and a water flea (*daphnia magna*) NOEC of 0.17 ppb.

Site Application Method	Rate in lbs ai per and # Apps.	EEC Peak (ppb)	EEC 21-Day Ave. (ppb)	Acute RQ (Peak EEC/LC50)[a]	Chronic RQ (21-Day EEC/NOEC)[b]
Alfalfa aerial	1.5 3	11.80	9.78	59.00	57.53
Almond aerial	3 1	8.89	7.94	44.45	46.71
Apples and Pears aerial	2 3	25.10	20.50	125.50	120.59
Berries aerial	2 5	75.40	65.60	377.00	385.88
Citrus aerial	10 2	386.00	312.00	1930.00	1835.29
Corn aerial	10 1	66.22	56.30	331.10	331.18
Cotton aerial	4 1	53.73	45.06	268.65	265.06
Cucumber broadcast	4 1	429.00	356.00	2145.00	2094.12

Table 77: Diazinon Risk Quotients for Freshwater Invertebrates Based On a scud (*Gammarus fasciatus*) LC50 of 0.2 ppb and a water flea (*daphnia magna*) NOEC of 0.17 ppb.

Site	Application Method	Rate in lbs ai per and	# Apps.	EEC Peak (ppb)	EEC 21-Day Ave. (ppb)	Acute RQ (Peak EEC/LC50)[a]	Chronic RQ (21-Day EEC/NOEC)[b]
Grape	aerial	1	5	10.70	9.10	53.50	53.53
Lawns	broadcast	4	3	182.30	157.80	911.50	928.24
Pineapple	ground	4	1	91.20	80.50	456.00	473.53
Potato	broadcast	10	1	181.75	147.25	908.75	866.18
Sorghum	broadcast	4	1	28.80	23.50	144.00	138.24
Soybean	aerial	4	1	38.80	31.20	194.00	183.53
Strawberry	aerial	1	4	112.00	98.80	560.00	581.18
Stone fruits (2)	aerial	2	3	25.10	20.50	125.50	120.59
Sugarcane	aerial	6	1	110.10	41.93	550.50	246.66
Sweet corn	aerial	1.25	5	71.10	57.30	355.50	337.06
Tobacco	aerial	4	1	62.67	51.87	313.33	305.09
Walnut	aerial	3	3	21.50	18.30	107.50	107.65

(1) Blackberry, Blueberry, Boysenberry, Dewberry, Loganberry, & Raspberry

(2) Apricot, Cherry, Nectarine, Peach, Plum and Prune

a RQ ≥ 0.5 exceeds acute high risk, acute restricted use and acute endangered species LOCs.
RQ ≥ 0.1 exceeds acute restricted use and acute endangered species risk LOCs.
RQ ≥ 0.05 exceeds acute endangered species risk LOC.
b RQ ≥ 1.00 exceeds chronic LOC.

The results indicate that the freshwater invertebrate aquatic acute high risk, restricted use, endangered species, and chronic levels of concern are exceeded for all registered use sites.

III. Estuarine/marine Fish. The acute and chronic risk quotients for estuarine/marine fish are tabulated below.

Table 78

Diazinon Risk Quotients for Estuarine/Marine Fish Based on a Striped Mullet (*Mugil cephalus*) LC50 of 150.0 ppb and a Sheepshead Minnow (*Cyprinodon variegatus*) NOEC of 0.39 ppb.

Site/Application Method/	Rate in lbs ai/A; # Apps		EEC Peak (ppb)	EEC 60-Day Ave. (ppb)	Acute RQ (Peak EEC/LC50)[a]	Chronic RQ (60-Day EEC/NOEC)[b]
Alfalfa Aerial	1.5	3	11.80	7.46	0.08	19.13
Almond aerial	3	1	8.89	6.39	0.06	16.38
Apples and Pears aerial	2	3	25.10	15.40	0.18	39.49
Berries (1) aerial	2	5	75.40	44.80	0.50	114.87
Citrus aerial	10	2	386.00	209.00	2.57	535.89
Corn aerial	10	1	66.22	41.73	0.44	107.00
Cotton aerial	4	1	53.73	35.87	0.36	91.97
Cucumber broadcast	4	1	429.00	258.00	2.86	661.54
Grape aerial	1	5	10.70	7.97	0.07	20.43
Lawns broadcast	4	3	182.30	129.00	1.22	330.77
Pineapple ground	4	1	91.20	67.20	0.61	172.31
Potato broadcast	10	1	181.75	114.25	1.21	292.95
Sorghum Broadcast	4	1	28.80	18.80	0.19	48.21
Soybean aerial	4	1	38.80	24.50	0.26	62.82
Strawberry aerial	1	4	112.00	83.00	0.75	212.82
Stone Fruits (2) aerial	2	3	25.10	15.40	0.18	39.49
Sugarcane aerial	6	1	110.10	79.65	0.73	204.23
Sweet corn Aerial	1.25	5	71.10	39.00	0.47	100.00
Tobacco aerial	4	1	62.67	42.27	0.42	108.38
Walnut aerial	3	3	21.50	16.20	0.14	41.54

(1) Blackberry, Blueberry, Boysenberry, Dewberry, Loganberry, & Raspberry

(2) Apricot, Cherry, Nectarine, Peach, Plum and Prune

a RQ $ 0.5 exceeds acute high risk, acute restricted use and acute endangered species LOCs.
RQ $ 0.1 exceeds acute restricted use and acute endangered species risk LOCs.
RQ $ 0.05 exceeds acute endangered species risk LOC.
b RQ $ 1.00 = exceeds chronic LOC.

The results indicate that the estuarine/marine fish aquatic acute high risk levels of concern are exceeded for berries, citrus, cucumber, lawns, pineapples, potatoes, strawberries, stone fruits and sugarcane. The acute restricted use risk level of concern is exceeded for all uses evaluated except alfalfa, almonds and grapes. The endangered species risk level of concern is exceeded for all uses evaluated. The estuarine/marine fish chronic risk levels of concern are exceeded for all diazinon use sites evaluated.

IV. Estuarine/Marine Invertebrates. The acute risk quotients for estuarine/marine invertebrates are tabulated below.

Table 79:

Diazinon Risk Quotients for Estuarine/Marine Aquatic Invertebrates Based on a Mysid (*Americamysis bahia*) EC50 of 4.2 ppb and NOEC of 0.23 ppb.

Site/Application Method/	Rate in lbs ai/A	No. of Apps.	EEC Peak (ppb)	EEC 21-Day Ave. (ppb)	Acute RQ (Peak EEC/EC50)[a]	Chronic RQ (21-Day EEC/NOEC)[b]
Alfalfa Aerial	1.5	3	11.80	9.78	2.81	42.52
Almond Aerial	3	1	8.89	7.94	2.12	34.52
Apples and Pears Aerial	2	3	25.10	20.50	5.98	89.13
Berries (1) Aerial	2	5	75.40	65.60	17.95	285.22
Citrus Aerial	10	2	386.00	312.00	91.90	1356.52
Corn Aerial	10	1	66.22	56.30	15.77	244.78
Cotton aerial	4	1	53.73	45.06	12.79	195.91
Cucumber broadcast	4	1	429.00	356.00	102.14	1547.83
Grape Aerial	1	5	10.70	9.10	2.55	39.57
Lawn Broadcast	4	3	182.30	157.80	43.40	686.09
Pineapple ground	4	1	91.20	80.50	21.71	350.00
Potato Broadcast	10	1	181.75	147.25	43.27	640.22
Sorghum Broadcast	4	1	28.80	23.50	6.86	102.17

Table 79:

Diazinon Risk Quotients for Estuarine/Marine Aquatic Invertebrates Based on a Mysid (*Americamysis bahia*) EC50 of 4.2 ppb and NOEC of 0.23 ppb.

Site/Application Method/	Rate in lbs ai/A	No. of Apps.	EEC Peak (ppb)	EEC 21-Day Ave. (ppb)	Acute RQ (Peak EEC/EC50)[a]	Chronic RQ (21-Day EEC/NOEC)[b]
Soybean Aerial	4	1	38.80	31.20	9.24	135.65
Strawberry Aerial	1	4	112.00	98.80	26.67	429.57
Stone Fruits (2) Aerial	2	3	25.10	20.50	5.98	89.13
Sugarcane aerial	6	1	110.10	41.93	26.21	182.30
Sweet corn aerial	1.25	5	71.10	57.30	16.93	249.13
Tobacco aerial	4	1	62.67	51.87	14.92	225.52
Walnut aerial	3	3	21.50	18.30	5.12	79.57

(1) Blackberry, Blueberry, Boysenberry, Dewberry, Loganberry, & Raspberry

(2) Apricot, Cherry, Nectarine, Peach, Plum and Prune

a RQ $ 0.5 exceeds acute high risk, acute restricted use and acute endangered species LOCs.
RQ $ 0.1 exceeds acute restricted use and acute endangered species risk LOCs.
RQ $ 0.05 exceeds acute endangered species risk LOC.
b RQ $ 1.00 = exceeds chronic LOC.

The results indicate that the estuarine/marine invertebrate aquatic acute high risk, restricted use, endangered species, and chronic levels of concern are exceeded for all diazinon registered use sites.

6. Risk Quotients for Nontarget Plants

I. Dry and Semi-aquatic Areas

Terrestrial plants inhabiting dry and semi-aquatic areas may be exposed to pesticides from runoff, spray drift or volatilization. Semi-aquatic areas are those low-lying wet areas that may be dry at certain times of the year. EFED's runoff scenario is: (1) based on a pesticide's water solubility and the amount of pesticide present on the soil surface and its top one inch, (2) characterized as "sheet runoff" (one treated acre to an adjacent acre) for dry areas, (3) characterized as "channelized runoff" (10 treated acres to a distant low-lying acre) for semi-aquatic areas, and (4) based on % runoff values of 0.01, 0.02, and 0.05 for water solubility of <10 ppm, 10-100 ppm, and >100 ppm, respectively.

Spray drift exposure from ground application is assumed to be 1% of the application rate. Spray drift from aerial, airblast, forced-air, and chemigation applications is assumed to be 5% of the application rate.

EECs are calculated for the following application methods: (1) unincorporated ground applications, (2) incorporated ground application, and (3) aerial, airblast, forced-air, and chemigation applications. Formulas for calculating EECs for dry areas adjacent to treatment sites and EECs for semi-aquatic areas are in an addendum. Estimated environmental concentrations for dry and semi-aquatic areas are tabulated below.

Table80
Diazinon Estimated Environmental Concentrations (lbs ai/A) For Dry and Semi-Aquatic Areas for a Single Application

Site/ Application Method/ Rate of Application in lbs ai/A	Minimum Incorporation Depth (cm)	Runoff Value	Sheet Runoff (lbs ai/A)	Channelized Runoff (lbs ai/A)	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channel Runoff+ Drift) (lbs ai/A)
Corn Unincorporated							
aerial 10.00	0.00	0.02	0.12	1.20	0.50	0.62	1.70
Corn Incorporated Ground 10.00	5.00	0.02	0.04	0.40	-	0.04	0.40
Cotton Unincorporated							
Ground 4.00	0.00	0.02	0.08	0.80	0.04	0.12	0.84
Forage Crops (1) Incorporate							

Table80

Diazinon Estimated Environmental Concentrations (lbs ai/A) For Dry and Semi-Aquatic Areas for a Single Application

Site/ Application Method/ Rate of Application in lbs ai/A	Minimum Incorporation Depth (cm)	Runoff Value	Sheet Runoff (lbs ai/A)	Channelized Runoff (lbs ai/A)	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channel Runoff+ Drift) (lbs ai/A)
Ground 4.00	5.00	0.02	0.02	0.16	-	0.02	0.16
Forage Crops (1) Unincorp							
aerial 4. 00	0.00	0.02	0.05	0.48	0.20	0.25	0.68
Ginseng Unincorporated							
Ground 0.50	0.00	0.02	0.01	0.10	0.00	0.02	0.11
Ginseng Unincorporated							
Chemigation 0.50	0.00	0.02	0.01	0.06	0.02	0.03	0.08
Sorghum & Soybean Incorp							
Ground 4.00	5.00	0.02	0.02	0.16	-	0.02	0.16
Sugarcane Unincorporated							
Ground 4.00	0.00	0.02	0.08	0.80	0.04	0.12	0.84
Sugarcane Unincorporated							
Aerial 4.00	0.00	0.02	0.05	0.48	0.20	0.25	0.68
Tobacco Incorporated							
Ground 4.00	5.00	0.02	0.02	0.16	-	0.02	0.16
Tobacco Unincorporated							
Aerial 4.00	0.00	0.02	0.05	0.48	0.20	0.25	0.68
Vegetable Crops (2) Incorpo							
Ground 4.00	5.00	0.02	0.02	0.16	-	0.02	0.16
Vegetable Crops (2) Uninco							
Aerial 4.00	0.00	0.02	0.05	0.48	0.20	0.25	0.68

Table80

Diazinon Estimated Environmental Concentrations (lbs ai/A) For Dry and Semi-Aquatic Areas for a Single Application

Site/ Application Method/ Rate of Application in lbs ai/A	Minimum Incorporation Depth (cm)	Runoff Value	Sheet Runoff (lbs ai/A)	Channelized Runoff (lbs ai/A)	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channel Runoff+ Drift) (lbs ai/A)
Vegetable Crops (3) Incorp							
Ground 10.00	5.00	0.02	0.04	0.40	-	0.04	0.40
Vegetable Crops (3) Uninco							
aerial 10.00	0.00	0.02	0.12	1.20	0.50	0.62	1.70

a Drift is not calculated if the chemical is incorporated at the time of application.

(1) Cowpea, Clover and Lespedeza.

(2) Typical Rates on the following crops: Beans (succulent), Beets (Table), Broccoli, Brussels Sprouts, Cabbage, Carrots, Cauliflower, Collards, Cucumber, Endive, Kale, Lettuce (Head & Table), Melons (Cantaloupes, Casabas, Crenshaws, Honeydews, Muskmelons, Persians, and hybrids of these and Watermelon) Mustard, Parsley, Parsnips, Peppers, Potatoes, Radishes, Rutabagas, Spinach, Squash (Summer & Winter), Sweet Corn, Sweet Potatoes, Swiss Chard, Tomatoes, Turnips (roots & tops) & Sugar Beets

(3) Maximum rates on the following crops: Bean, Beet, Broccoli, Brussels Sprouts, Cabbage, Carrot, Cauliflower, Celery, Collard, Cucumber, Endive, Kale, Lettuce, Melon, Mustard, Onion, Peas, Potato, Radish, Sweet Corn, Sweet Potato and Tomato

The EC25 value of the most sensitive species in the seedling emergence study is compared to runoff and drift exposure to determine the risk quotient (EEC/toxicity value). The EC25 value of the most sensitive species in the vegetative vigor study is compared to the drift exposure to determine the acute risk quotient.

EECs and acute high risk quotients for terrestrial and semi-aquatic plants based on a single application are tabulated below.

Table 81

Diazinon Acute High Risk Quotients from a Single Application for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On Oat Emergence EC25 of 5.26 lb ai/A, Cucumber Vegetative Vigor EC25 of 3.23 lb ai/A.

Site, Method and Rate of Application (lbs ai/A)	Drift (lbs ai/A)a	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Corn Unincorporated						
Aerial 10.00	0.50	0.62	1.70	0.118	0.32	0.15
Corn Incorporated						

Table 81

Diazinon Acute High Risk Quotients from a Single Application for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On Oat Emergence EC25 of 5.26 lb ai/A, Cucumber Vegetative Vigor EC25 of 3.23 lb ai/A.

Site, Method and Rate of Application (lbs ai/A)	Drift (lbs ai/A)a	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Ground 10.00	-	0.04	0.40	0.008	0.08	0.00
Cotton Unincorporated						
Ground 4.00	0.04	0.12	0.84	0.023	0.16	0.01
Forage Crops (1) Incorporated						
Ground 4.00	-	0.02	0.16	0.004	0.03	0.00
Forage Crops (1) Unincorporated						
Aerial 4.00	0.20	0.25	0.68	0.048	0.13	0.06
Ginseng Unincorporated						
Ground 0.50	0.01	0.02	0.11	0.004	0.02	0.00
Ginseng Unincorporated						
Chemigation 0.50	0.03	0.03	0.08	0.006	0.02	0.01
Sorghum Incorporated						
Ground 4.00	-	0.02	0.16	0.004	0.03	0.00
Soybean Incorporated						
Ground 4.00	-	0.02	0.16	0.004	0.03	0.00
Sugarcane Unincorporated						
Ground 4.00	0.04	0.12	0.84	0.023	0.16	0.01
Sugarcane Unincorporated						
Aerial 4.00	0.20	0.25	0.68	0.048	0.13	0.06
Tobacco Incorporated						
Ground 4.00	-	0.02	0.16	0.004	0.03	0.00
Tobacco Unincorporated						
Aerial 4.00	0.20	0.25	0.68	0.048	0.13	0.06
Vegetable Crops (2) incorporated						
ground 4.00	-	0.02	0.16	0.004	0.03	0.00
Vegetable Crops (2)						
aerial 4.00	0.20	0.25	0.68	0.048	0.13	0.06

Table 81
Diazinon Acute High Risk Quotients from a Single Application for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On Oat Emergence EC25 of 5.26 lb ai/A, Cucumber Vegetative Vigor EC25 of 3.23 lb ai/A.

Site, Method and Rate of Application (lbs ai/A)	Drift (lbs ai/A)a	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Vegetable Crops (3) incorporated						
Ground 10.00	-	0.04	0.40	0.008	0.08	0.00
Vegetable Crops (3)						
aerial 10.00	0.50	0.62	1.70	0.118	0.32	0.15

a Drift is not calculated if the chemical is incorporated at the time of application.

b RQ > 1.0 exceeds acute high risk LOCs.

(1) Cowpea, Clover and Lespedeza.

(2) Typical Rates on the following crops: Beans (succulent), Beets (Table), Broccoli, Brussels Sprouts, Cabbage, Carrots, Cauliflower, Collards, Cucumber, Endive, Kale, Lettuce (Head & Table), Melons (Cantaloupes, Casabas, Crenshaws, Honeydews, Muskmelons, Persians, and hybrids of these and Watermelon) Mustard, Parsley, Parsnips, Peppers, Potatoes, Radishes, Rutabagas, Spinach, Squash (Summer & Winter), Sweet Corn, Sweet Potatoes, Swiss Chard, Tomatoes, Turnips (roots & tops) & Sugar Beets

(3) Maximum rates on the following crops: Bean, Beet, Broccoli, Brussels Sprouts, Cabbage, Carrot, Cauliflower, Celery, Collard, Cucumber, Endive, Kale, Lettuce, Melon, Mustard, Onion, Peas, Potato, Radish, Sweet Corn, Sweet Potato and Tomato

The results indicate that for a single application, acute high risk levels of concern are not exceeded for terrestrial and semi-aquatic plants for the registered application rates of diazinon. Currently, EFED does not perform assessments for chronic risk to terrestrial and semi-aquatic plants.

The NOEC or EC05 (if NOEC is unavailable) value of the most sensitive species in the seedling emergence study is compared to runoff and drift exposure to determine the endangered species risk quotient. The NOEC or EC05 value of the most sensitive species in the vegetative vigor study is compared to the drift exposure to determine the endangered species risk quotient.

EECs and acute (endangered species) risk quotients for terrestrial plants based on a single application are tabulated below.

Table 82

Diazinon Acute Endangered Species Risk Quotients from a Single Application for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On Oat Emergence EC05 of 0.17 lb ai/A and Cucumber Vegetative Vigor EC05 of 1.27 lb ai/A.

Site, Method and Rate of Application (lbs ai/A)	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas
Corn Unincorporated						
Aerial 10.00	0.50	0.62	1.70	3.65	10.00	0.39
Corn Incorporated						
Ground 10.00	-	0.04	0.40	0.24	2.35	0.00
Cotton Unincorporated						
Ground 4.00	0.04	0.12	0.84	0.71	4.94	0.03
Forage Crops (1) Incorporated						
Ground 4.00	-	0.02	0.16	0.12	0.94	0.00
Forage Crops (1) Unincorporated						
Aerial 4.00	0.20	0.25	0.68	1.47	4.00	0.16
Ginseng Unincorporated						
Ground 0.50	0.01	0.02	0.11	0.12	0.65	0.00
Ginseng Unincorporated						
Chemigation 0.50	0.03	0.03	0.08	0.18	0.47	0.02
Sorghum/Soybean Incorporated						
Ground 4.00	-	0.02	0.16	0.12	0.94	0.00
Sugarcane Unincorporated						
Ground 4.00	0.04	0.12	0.84	0.71	4.94	0.03
Sugarcane Unincorporated						
Aerial 4.00	0.20	0.25	0.68	1.47	4.00	0.16
Tobacco Incorporated						
Ground 4.00	-	0.02	0.16	0.12	0.94	0.00
Tobacco Unincorporated						
Aerial 4.00	0.20	0.25	0.68	1.47	4.00	0.16
Vegetable Crops (2) Incorporated						
Ground 4.00	-	0.02	0.16	0.12	0.94	0.00
Vegetable Crops (2) Unincorporated						
Aerial 4.00	0.20	0.25	0.68	1.47	4.00	0.16

Table 82

Diazinon Acute Endangered Species Risk Quotients from a Single Application for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On Oat Emergence EC05 of 0.17 lb ai/A and Cucumber Vegetative Vigor EC05 of 1.27 lb ai/A.

Site, Method and Rate of Application (lbs ai/A)	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas
Vegetable Crops (3) Incorporated						
Ground 10.00	-	0.04	0.40	0.24	2.35	0.00
Vegetable Crops (3) Unincorporated						
Aerial 10.00	0.50	0.62	1.70	3.65	10.00	0.39

a Drift is not calculated if the chemical is incorporated at the time of application.

b RQ >1.0 exceeds endangered species risk LOCs.

(1) Cowpea, Clover and Lespedeza.

(2) Typical Rates on the following crops: Beans (succulent), Beets (Table), Broccoli, Brussels Sprouts, Cabbage, Carrots, Cauliflower, Collards, Cucumber, Endive, Kale, Lettuce (Head & Table), Melons (Cantaloupes, Casabas, Crenshaws, Honeydews, Muskmelons, Persians, and hybrids of these and Watermelon) Mustard, Parsley, Parsnips, Peppers, Potatoes, Radishes, Rutabagas, Spinach, Squash (Summer & Winter), Sweet Corn, Sweet Potatoes, Swiss Chard, Tomatoes, Turnips (roots & tops) & Sugar Beets

(3) Maximum rates on the following crops: Bean, Beet, Broccoli, Brussels Sprouts, Cabbage, Carrot, Cauliflower, Celery, Collard, Cucumber, Endive, Kale, Lettuce, Melon, Mustard, Onion, Peas, Potato, Radish, Sweet Corn, Sweet Potato and Tomato

The results indicate that, for a single application, endangered species levels of concern are exceeded for terrestrial and semi-aquatic plants at the registered application rates of diazinon to corn, forage crops (see table above), sugarcane, tobacco and vegetable crops (see table above) using aerial applications. Also, for a single application, endangered species levels of concern are exceeded for semi-aquatic plants at the registered application rates of diazinon for ground applications to corn, cotton, sugarcane and vegetable crops (at the 10 lb ai/A rate). The RQs exceeded are shaded in the above table.

EECs and high acute risk quotients for terrestrial plants in dry and semi-aquatic areas based on multiple applications of diazinon are tabulated below.

Table 83

Diazinon Acute High Risk Quotients from Multiple Applications for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On an Oat Emergence EC25 of 5.26 lb ai/A and a Cucumber Vegetative Vigor EC25 of 3.23 lb ai/A.

Site, Method, Rate of Application (lbs ai/A) and # of Apps per year.	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Almond Unincorporated						
Ground 3/3	0.09	0.27	1.89	0.05	0.36	0.03

Table 83

Diazinon Acute High Risk Quotients from Multiple Applications for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On an Oat Emergence EC25 of 5.26 lb ai/A and a Cucumber Vegetative Vigor EC25 of 3.23 lb ai/A.

Site, Method, Rate of Application (lbs ai/A) and # of Apps per year.	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Almond Unincorporated Aerial 3/3	0.45	0.56	1.53	0.11	0.29	0.14
Apples and Pear Unincorporated Ground 2/3	0.06	0.18	1.26	0.03	0.24	0.02
Apples and Pear Unincorporated Aerial 2/3	0.30	0.37	1.02	0.07	0.19	0.09
Banana (HI, only) Unincorporated Ground 0.5/3 (A)	0.02	0.04	0.32	0.01	0.06	0.005
Berries (1) Unincorporated Ground 2/5	0.10	0.30	2.10	0.06	0.40	0.03
Berries (1) Unincorporated Aerial 2/5	0.50	0.62	1.22	0.12	0.23	0.15
Cranberries Unincorporated Ground 3/4	0.12	0.36	2.52	0.07	0.48	0.04
Cranberries Unincorporated Aerial 3/4	0.60	0.74	2.04	0.14	0.39	0.19
Fig Unincorporated Ground 0.5/3 (A)	0.02	0.04	0.32	0.01	0.06	0.005
Filbert Unincorporated Ground 2/3 (A)	0.06	0.18	1.26	0.03	0.24	0.02
Forage Crops (2) Unincorporated Ground 1.5/3 (A)	0.04	0.14	0.94	0.03	0.18	0.01
Forage Crops (2) Unincorporated Aerial 1.5/3 (A)	0.22	0.28	0.76	0.05	0.15	0.07
Forage Crops (3) Unincorporated Ground 0.5/3 (A)	0.02	0.04	0.32	0.01	0.06	0.005
Forage Crops (3) Unincorporated						

Table 83

Diazinon Acute High Risk Quotients from Multiple Applications for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On an Oat Emergence EC25 of 5.26 lb ai/A and a Cucumber Vegetative Vigor EC25 of 3.23 lb ai/A.

Site, Method, Rate of Application (lbs ai/A) and # of Apps per year.	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Aerial 0.5/3 (A)	0.08	0.09	0.26	0.02	0.05	0.02
Grapes Unincorporated						
Ground 1/5	0.05	0.15	1.05	0.03	0.20	0.02
Grapes Unincorporated						
Aerial 1/5	0.25	0.31	0.85	0.06	0.16	0.08
Grasses (seed crop) Unincorporated						
Ground 1/3 (A)	0.03	0.09	0.63	0.02	0.12	0.01
Grasses (seed crop) Unincorporated						
Aerial 1/3 (A)	0.15	0.19	0.51	0.04	0.10	0.05
Miscellaneous Crops (CA, only) (4) Unincorp						
Ground 5/3	0.15	0.45	3.15	0.09	0.60	0.05
Olive Unincorporated						
Ground 0.5/3 (A)	0.02	0.04	0.32	0.01	0.06	0.005
Peanuts Incorporated						
Ground 2/4	-	0.16	1.60	0.03	0.30	0.00
Peanuts Unincorporated						
Aerial 2/4	0.40	0.50	1.36	0.09	0.26	0.12
Pecan Unincorporated						
Ground 3/3 (A)	0.09	0.27	1.89	0.05	0.36	0.03
Pineapple Unincorporated						
Ground 2/8	0.16	0.48	3.36	0.09	0.64	0.05
Strawberries & Hops Incorporated						
Ground 1/4	-	0.08	0.80	0.02	0.15	0.00
Strawberries & Hops Unincorporated						
Ground 1/4	0.04	0.12	0.84	0.02	0.16	0.01

Table 83

Diazinon Acute High Risk Quotients from Multiple Applications for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On an Oat Emergence EC25 of 5.26 lb ai/A and a Cucumber Vegetative Vigor EC25 of 3.23 lb ai/A.

Site, Method, Rate of Application (lbs ai/A) and # of Apps per year.	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Strawberries & Hops Unincorporated						
Aerial 1/4	0.20	0.25	0.68	0.05	0.13	0.06
Stone Fruits (6) Unincorporated						
Ground 2/3	0.06	0.18	1.26	0.03	0.24	0.02
Stone Fruits (6) Unincorporated						
aerial/chemigation 2/3	0.30	0.37	1.02	0.07	0.19	0.09
Sweet Corn Unincorporated						
Ground 1.25/5	0.06	0.19	1.31	0.04	0.25	0.02
Sweet Corn Unincorporated						
aerial/chemigation 1.25/5	0.31	0.39	1.06	0.07	0.20	0.10
Walnuts (CA, only) Unincorporated						
Ground 3/3	0.09	0.27	1.89	0.05	0.36	0.03
Walnuts (CA, only) Unincorporated						
Aerial 3/3	0.45	0.56	1.53	0.11	0.29	0.14
Watercress Unincorporated						
Ground 0.5/3 (A)	0.02	0.04	0.32	0.01	0.06	0.005
Watercress Unincorporated						
Aerial 0.5/3 (A)	0.08	0.09	0.26	0.02	0.05	0.02
Forest Trees Unincorporated						
Ground 1.5/3 (B)	0.04	0.14	0.94	0.03	0.18	0.01
Ornamentals (7) Unincorporated						
Ground 1.5/3 (B)	0.04	0.14	0.94	0.03	0.18	0.01
Ornamentals (7) Unincorporated						
Aerial 1.5/3 (B)	0.22	0.28	0.76	0.05	0.15	0.07
Ornamental Lawns & Turf Unincorporated						
Ground 4/3 (A)	0.12	0.36	2.52	0.07	0.48	0.04

Table 83

Diazinon Acute High Risk Quotients from Multiple Applications for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On an Oat Emergence EC25 of 5.26 lb ai/A and a Cucumber Vegetative Vigor EC25 of 3.23 lb ai/A.

Site, Method, Rate of Application (lbs ai/A) and # of Apps per year.	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Nonfood sites (8) Unincorporated						
Ground 0.5/3 (A)	0.02	0.04	0.32	0.01	0.06	0.005
Nonfood sites (8) Unincorporated						
Aerial 0.5/3 (A)	0.08	0.09	0.26	0.02	0.05	0.02
Wide Area General Outdoor (Public Health)						
Unincorporated						
Ground 1/3 (A)	0.03	0.09	0.63	0.02	0.12	0.01
Wide Area General Outdoor (Public Health)						
Unincorporated						
Aerial 1/3 (A)	0.15	0.19	0.51	0.04	0.10	0.05

a Drift is not calculated if the chemical is incorporated at the time of application.

b RQ >1.0 exceeds acute high risk LOCs..

(1) Blackberry, Blueberry, Boysenberry, Dewberry, Loganberry, & Raspberry

(2) Alfalfa. Alfalfa Clover Mixture, Trefoil,

(3) Bermuda grass, Grass, Guar, Pasture and Rangeland.

(4) Quarantine crops (CA, only) - Almond, Apple, Apricot, Bean, Bushberry, Cherry, Citrus, Corn, Cucumber, Fig, Filbert, Grape, Kiwi, Melon Nectarine, Olive, Peach, Pear, Peas, Pecan, Pepper, Plum, Prune, Strawberry, Squash, Tomato, Walnut, Ornamental, & Cannery Waste.

(5) Typical Rates on the following crops: Apricot, Cherry, Nectarine, Peach, Plum and Prune

(6) Herbaceous plants, nonflowering plants, shade trees, woody shrubs & vines)

(7) Drainage systems, nonagricultural rights-of-way/ fencerows/hedgerows, and nonagricultural uncultivated areas/soils.

(A) Three applications used in table but label indicates; "Repeat as necessary."

(B) Three applications used in table but label indicates; "Repeat as necessary." Rate based on 100 gal/A finished spray.

The results indicate that, for multiple applications, acute high risk levels of concern are not exceeded for terrestrial and semi-aquatic plants for the registered application rates of diazinon.

EECs and acute (endangered species) risk quotients for terrestrial plants based on multiple applications of diazinon are tabulated below.

Table 84

Diazinon Acute Endangered Species Risk Quotients from Multiple Applications for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On Oat Emergence EC05 of 0.17 lb ai/A and Cucumber Vegetative Vigor EC05 of 1.27 lb ai/A.

Site, Method, Rate of Application (lbs ai/A) and # of Apps.	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Almond Unincorporated Ground 3/3	0.09	0.27	1.89	1.59	11.12	0.07
Almond Unincorporated Aerial 3/3	0.45	0.56	1.53	3.28	9.00	0.35
Apples and Pear Unincorporated Ground 2/3	0.06	0.18	1.26	1.06	7.41	0.05
Apples and Pear Unincorporated Aerial 2/3	0.30	0.37	1.02	2.19	6.00	0.24
Banana (HI, only) Unincorporated Ground 0.5/3 (A)	0.02	0.04	0.32	0.26	1.85	0.01
Berries (1) Unincorporated Ground 2/5	0.10	0.30	2.10	1.76	12.35	0.08
Berries (1) Unincorporated Aerial 2/5	0.50	0.62	1.22	3.65	7.18	0.39
Cranberries Unincorporated Ground 3/4	0.12	0.36	2.52	2.12	14.82	0.09
Cranberries Unincorporated Aerial 3/4	0.60	0.74	2.04	4.38	12.00	0.47
Fig Unincorporated Ground 0.5/3 (A)	0.02	0.04	0.32	0.26	1.85	0.01
Filbert Unincorporated Ground 2/3 (A)	0.06	0.18	1.26	1.06	7.41	0.05
Forage Crops (2) Unincorporated Ground 1.5/3 (A)	0.04	0.14	0.94	0.79	5.56	0.04
Forage Crops (2) Unincorporated Aerial 1.5/3 (A)	0.22	0.28	0.76	1.64	4.50	0.18
Forage Crops (3) Unincorporated						

Table 84

Diazinon Acute Endangered Species Risk Quotients from Multiple Applications for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On Oat Emergence EC05 of 0.17 lb ai/A and Cucumber Vegetative Vigor EC05 of 1.27 lb ai/A.

Site, Method, Rate of Application (lbs ai/A) and # of Apps.	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Ground 0.5/3 (A)	0.02	0.04	0.32	0.26	1.85	0.01
Forage Crops (3) Unincorporated						
Aerial 0.5/3 (A)	0.08	0.09	0.26	0.55	1.50	0.06
Grapes Unincorporated						
Ground 1/5	0.05	0.15	1.05	0.88	6.18	0.04
Grasses (seed crop) Unincorporated						
Ground 1/3 (A)	0.03	0.09	0.63	0.53	3.71	0.02
Grasses (seed crop) Unincorporated						
Aerial 1/3 (A)	0.15	0.19	0.51	1.09	3.00	0.12
Miscellaneous Crops (CA, only) (4) Unincorporated						
Ground 5/3	0.15	0.45	3.15	2.65	18.53	0.12
Olive Unincorporated						
Ground 0.5/3 (A)	0.02	0.04	0.32	0.26	1.85	0.01
Peanuts Incorporated						
Ground 2/4	-	0.16	1.60	0.94	9.41	0.00
Peanuts Unincorporated						
Aerial 2/4	0.40	0.50	1.36	2.92	8.00	0.32
Pecan Unincorporated						
Ground 3/3 (A)	0.09	0.27	1.89	1.59	11.12	0.07
Pineapple Unincorporated						
Ground 2/8	0.16	0.48	3.36	2.82	19.76	0.13
Strawberries & Hops Incorporated						
Ground 1/4	-	0.08	0.80	0.47	4.71	0.00
Strawberries & Hops Unincorporated						
Ground 1/4	0.04	0.12	0.84	0.71	4.94	0.03

Table 84

Diazinon Acute Endangered Species Risk Quotients from Multiple Applications for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On Oat Emergence EC05 of 0.17 lb ai/A and Cucumber Vegetative Vigor EC05 of 1.27 lb ai/A.

Site, Method, Rate of Application (lbs ai/A) and # of Apps.	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Strawberries & Hops Unincorporated						
Aerial 1/4	0.20	0.25	0.68	1.46	4.00	0.16
Stone Fruits (6) Unincorporated						
Ground 2/3	0.06	0.18	1.26	1.06	7.41	0.05
Stone Fruits (6) Unincorporated						
aerial/chemigation 2/3	0.30	0.37	1.02	2.19	6.00	0.24
Sweet Corn Unincorporated						
Ground 1.25/5	0.06	0.19	1.31	1.10	7.72	0.05
Sweet Corn Unincorporated						
aerial/chemigation 1.25/5	0.31	0.39	1.06	2.28	6.25	0.25
Walnuts (CA, only) Unincorporated						
Ground 3/3	0.09	0.27	1.89	1.59	11.12	0.07
Walnuts (CA, only) Unincorporated						
Aerial 3/3	0.45	0.56	1.53	3.28	9.00	0.35
Watercress Unincorporated						
Ground 0.5/3 (A)	0.02	0.04	0.32	0.26	1.85	0.01
Watercress Unincorporated						
Aerial 0.5/3 (A)	0.08	0.09	0.26	0.55	1.50	0.06
Forest Trees Unincorporated						
Ground 1.5/3 (B)	0.04	0.14	0.94	0.79	5.56	0.04
Ornamentals (7) Unincorporated						
Ground 1.5/3 (B)	0.04	0.14	0.94	0.79	5.56	0.04
Ornamentals (7) Unincorporated						
Aerial 1.5/3 (B)	0.22	0.28	0.76	1.64	4.50	0.18

Table 84

Diazinon Acute Endangered Species Risk Quotients from Multiple Applications for Terrestrial Plants in Dry and Semi-Aquatic Areas Based On Oat Emergence EC05 of 0.17 lb ai/A and Cucumber Vegetative Vigor EC05 of 1.27 lb ai/A.

Site, Method, Rate of Application (lbs ai/A) and # of Apps.	Drift (lbs ai/A)[a]	Total Loading to Adjacent Area (Sheet Runoff+ Drift) (lbs ai/A)	Total Loading to Semi-aquatic Area (Channelized Runoff+ Drift) (lbs ai/A)	Emergence RQ Dry Area[b]	Emergence RQ Semi-Aquatic Area[b]	Vegetative Vigor RQ Both Areas[b]
Ornamental Lawns & Turf Unincorporated						
Ground 4/3 (A)	0.12	0.36	2.52	2.12	14.82	0.09
Nonfood sites (8) Unincorporated						
Ground 0.5/3 (A)	0.02	0.04	0.32	0.26	1.85	0.01
Nonfood sites (8) Unincorporated						
Aerial 0.5/3 (A)	0.08	0.09	0.26	0.55	1.50	0.06
Wide Area General Outdoor (Public Health) Unincorporated						
Ground 1/3 (A)	0.03	0.09	0.63	0.53	3.71	0.02
Wide Area General Outdoor (Public Health) Unincorporated						
Aerial 1/3 (A)	0.15	0.19	0.51	1.09	3.00	0.12

a Drift is not calculated if the chemical is incorporated at the time of application.

b RQ > 1.0 exceeds endangered species risk LOCs.

(1) Blackberry, Blueberry, Boysenberry, Dewberry, Loganberry, & Raspberry

(2) Alfalfa. Alfalfa Clover Mixture, Trefoil,

(3) Bermuda grass, Grass, Guar, Pasture and Rangeland.

(4) Quarantine crops (CA, only) - Almond, Apple, Apricot, Bean, Bushberry, Cherry, Citrus, Corn, Cucumber, Fig, Filbert, Grape, Kiwi, Melon Nectarine, Olive, Peach, Pear, Peas, Pecan, Pepper, Plum, Prune, Strawberry, Squash, Tomato, Walnut, Ornamental, & Cannery Waste.

(5) Typical Rates on the following crops: Apricot, Cherry, Nectarine, Peach, Plum and Prune

(6) Herbaceous plants, nonflowering plants, shade trees, woody shrubs & vines)

(7) Drainage systems, nonagricultural rights-of-way/ fencerows/hedgerows, and nonagricultural uncultivated areas/soils.

(A) Three applications used in table but label indicates; "Repeat as necessary."

(B) Three applications used in table but label indicates; "Repeat as necessary." Rate based on 100 gal/A finished spray.

The results indicate that, for multiple applications, endangered species levels of concern are exceeded for terrestrial plants in dry areas at all the registered application uses and rates of diazinon except for: 1) the unincorporated/ground uses on: banana, cranberries, forage crops (see table above), grapes, grasses (seed crop), olive, strawberries, hops, watercress, forest trees, ornamentals (see table above) and the nonfood sites (see table above); 2) the incorporated/ground applications on peanuts, strawberries and hops; and 3) unincorporated/aerial applications to watercress. The endangered species levels of concern are exceeded for terrestrial plants in semi-aquatic areas for all registered uses and application rates of diazinon.

ii. Aquatic Plants

Exposure to nontarget aquatic plants may occur through runoff or spray drift from adjacent treated sites or directly from such uses as aquatic weed or mosquito larvae control. An aquatic plant risk assessment for acute high risk is usually made for aquatic vascular plants from the surrogate duckweed *Lemna gibba*. Non-vascular acute high aquatic plant risk assessments are performed using either algae or a diatom, whichever is the most sensitive species. An aquatic plant risk assessment for acute endangered species is usually made for aquatic vascular plants from the surrogate duckweed *Lemna gibba*. To date there are no known non-vascular plant species on the endangered species list. Runoff and drift exposure is computed from PRIZM3/EXAMS 2.95. The risk quotient is determined by dividing the pesticide's initial or peak concentration in water by the plant EC50 value.

Acute risk quotients for non-vascular plants are tabulated below.

Table 85
Acute Risk Quotients for Aquatic Plants based on a nonvascular plant, green algae (*Selenastrum capricornutum*) EC50 of 3.7 ppm (3700 ppb) ai.

Site/ Rate of Application	Application Method	(lbs ai/A)/No. of Apps.	Peak EEC (ppb)	Non-target plant RQ (EEC/EC50)[a]
Alfalfa	aerial	1.5/3	11.80	0.003
Almond 1 @ 3.00	aerial	3/ 1	8.89	0.002
Apples and Pear	aerial	2/3	25.10	0.007
Berries (1)	aerial	2/5	75.40	0.020
Citrus	aerial	10/2	386.00	0.104
Corn	aerial	10/1	66.22	0.018
Cotton	aerial	4/1	53.73	0.015
Cucumber	broadcast	4/1	429.00	0.110
Grape	aerial	1/5	10.70	0.003
Lawns	broadcast	4/3	182.30	0.049
Pineapple	ground	4/1	91.20	0.025

Table 85

Acute Risk Quotients for Aquatic Plants based on a nonvascular plant, green algae (*Selenastrum capricornutum*) EC50 of 3.7 ppm (3700 ppb) ai.

Site/ Rate of Application	Application Method	(lbs ai/A)/No. of Apps.	Peak EEC (ppb)	Non-target plant RQ (EEC/EC50)[a]
Potato	broadcast	10/1	181.75	0.049
Sorghum	broadcast	4/1	28.80	0.008
Soybean	aerial	4/1	38.80	0.010
Strawberry	aerial	1/4	112.00	0.030
Stone Fruits (2)	aerial	2/3	25.10	0.007
Sugarcane	aerial	6/1	110.10	0.030
Sweet Corn	aerial	1.25/5	71.10	0.019
Tobacco	aerial	4/1	62.67	0.017
Walnut	aerial	3/3	21.50	0.006

a RQ > 1.0 exceeds acute high risk LOCs.

(1) Blackberry, Blueberry, Boysenberry, Dewberry, Loganberry, & Raspberry

(2) Apricot, Cherry, Nectarine, Peach, Plum and Prune

The results indicate that, for single or multiple applications, the non-vascular acute high aquatic plant risk levels of concern are not exceeded for the registered application rates of diazinon. The non-target vascular plant acute high and endangered species risk levels of concern cannot be assessed at this time due to the lack of data. The need for the submission of a Tier I study (guideline 122-2) for the test species, *Lemna gibba* (duckweed), to fulfill this data gap has been mentioned previously.

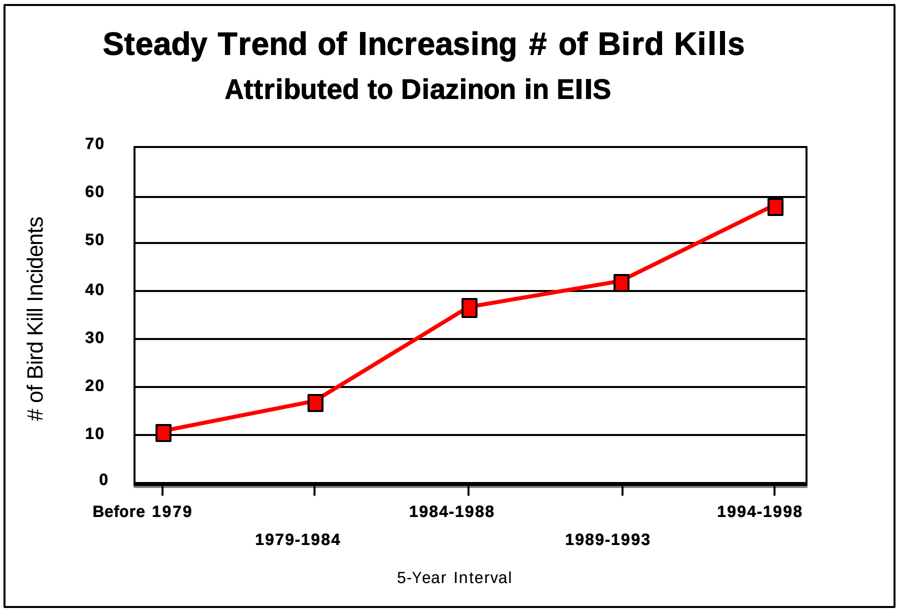
ECOLOGICAL INCIDENTS SUMMARY

Ecological Incidents. Based on information available in the USEPA Ecological Incident Information System (EIIS), diazinon has caused the second largest number of total known incidents of bird mortality of any pesticide, exceeded only by carbofuran (a largely agricultural pesticide with many of its granular uses phased out). Diazinon has the highest number of bird mortality incidents (58) caused by any pesticide in the past five years (1994-1998) and it has the highest total number per million acres treated. There has been a trend in the EIIS of steadily increasing numbers of diazinon-related incidents over the years, with 11 incidents occurring before 1979 and 17, 37, 42, and 58 incidents, respectively over each of the subsequent 5-year periods (See Figure 1). Diazinon has high use on lawns and other turf, and the majority of incidents on known sites have occurred here, with the remaining incidents on a variety of residential, agricultural, or unknown sites. In many cases, diazinon is well documented as the causative agent, but the specific site or source (e.g., turf) is not reported in incident reports submitted to EPA.

The number of documented kills, while very large, is believed to be but a very small fraction of total mortality caused by this pesticide. Mortality incidents must be seen, reported, investigated, and have investigation reports submitted to EPA to have the potential to get entered into a database. Incidents often are not seen, due to scavenger removal of carcasses, decay in a field, or simply because carcasses may be hard to see on many sites and/or few people are systematically looking. Poisoned birds may also move off-site to less conspicuous areas before dying. Incidents seen may not get reported to appropriate authorities capable of investigating the incident because the finder may not know of the importance of reporting incidents, may not know who to call, may not feel they have the time or desire to call, may hesitate to call because of their own involvement in the kill, or the call may be long-distance and discourage callers, for example. Incidents reported may not get investigated if resources are limited or may not get investigated thoroughly, with residue and ChE analyses, for example. Also, if kills are not reported and investigated promptly, there will be little chance of documenting the cause, since tissues and residues may deteriorate quickly. Reports of investigated incidents often do not get submitted to EPA, since reporting by states is voluntary and some investigators may believe that they don't have the resources to submit incident reports to EPA.

Incidents reports submitted to EPA since approximately 1994 have been tracked by assignment of I-#s in an Incident Data System (IDS), microfiched, and then entered to a second database, the Ecological Incident Information System (EIIS). This second database has some 85 fields for potential data entry. An effort has also been made to enter information to EIIS on incident reports received prior to establishment of current databases. Although many of these have been added, the system is not yet a complete listing of all incident reports received by EPA. Incident reports are not received in a consistent format (e.g., states and various labs usually have their own formats), may involve multiple incidents involving multiple chemicals in one report, and may report on only part of a given incident investigation (e.g., residues). While some progress

Figure 1.



Steady Trend of Increasing # of Bird Kills
Attributed to Diazinon in EIIS
70
60
50
40
30
20
10
0
# of Bird Kill Incidents
Before 1979
1979-1984
1984-1988
1989-1993
1994-1998
5-Year Interval

has been made in recent years, both in getting incident reports submitted and entered, there has never been the level of resources assigned to incidents that there has been to the tracking and review of laboratory toxicity studies, for example. This adds to the reasons cited above for why EPA believes the documented kills are but a fraction of total mortality caused by diazinon and other highly toxic pesticides.

Diazinon incidents played an important role in the cancellation of diazinon on golf courses and sod farms in March 1988, following lengthy hearings in 1987. Some 52 incidents on golf course and other turf sites were presented and sustained under intensive cross-examination (Ward Stone, 1987). A number of particularly large waterfowl kills had occurred on golf courses.

A comparison of these 52 incidents with those in the EIIS database (as of 12/17/98) indicates that approximately 17 appear to be in the database, 32 appear not to be there (but will be added), and 3 are uncertain (i.e., similarities to existing entries, but not as clear as for the above 17). Even for those that appear to be in the database, where additional information is available it will be added to the database.

Incidents have continued to occur on remaining use sites, especially lawn and other turf sites. Waterfowl are especially attracted to sites that have water bodies nearby. Non-waterfowl can be attracted to nearly any vegetated site (and many nonvegetated sites), although those with food, shelter, and/or water can be the most attractive. Roughly 200 additional incidents have been reported, most occurring since 1987 (but many spread over the past 25 years).

Incidents have occurred with both liquid and granular formulations of diazinon. Incidents have occurred despite watering in (irrigation) on turf, possibly due to residues still on the turf blades or in the thatch, or due to puddling (water can attract birds). Birds can receive a lethal dose quite quickly, as was shown in a field study in 1987 when 85 wigeon were killed on treated turf in just 30-40 minutes of feeding. This mortality was at an attempted 2 lb/A application rate of a liquid formulation, well below current label rates, indicating that diazinon is toxic enough to birds that most reductions of application rates are not likely to prevent mortality.

For granular diazinon, it has been demonstrated that small birds can be killed with just 1-5 granules (14% ai). If granules had less diazinon per granule it would take more granules to kill a given bird, but given the very small size of the granules, and their propensity to either stick to other food items (e.g., invertebrates) or to be picked up directly (possibly as grit), most reductions here would not be sufficient to prevent mortality, either. Birds have even died because of indoor use of a micro-encapsulated product. Some of the material was apparently swept out of a concession stand and birds were exposed.

Incidents entered into EIIS are categorized into one of several certainty levels: highly probable, probable, possible, unlikely, or unrelated. In brief, “highly probable” incidents usually require carcass residues, substantial ChE inhibition (for chemicals such as diazinon and other organophosphates that depress brain and blood cholinesterase), and/or clear circumstances regarding the exposure. "Probable" incidents include those where residues were not available and/or circumstances were less clear than for "highly probable." "Possible" incidents include those where multiple chemicals may have been involved and it is not clear what the contribution was of a given chemical. The "unlikely" category is used, for example, where a given chemical is practically nontoxic to the category of organism killed and/or the chemical was tested for but not detected in samples. "Unrelated" incidents are those that have been confirmed to be not pesticide-related.

Incidents entered into EIIS are also categorized as to use/misuse. Unless specifically confirmed by a state or federal agency to be misuse, or there was very clear misuse such as intentional baiting to kill wildlife, incidents would not typically be considered misuse. Data entry personnel often do not have a copy of the specific label used in a given application, and would not usually be able to detect a variety of label-specific violations, for example.

An attempt has been made to further categorize diazinon incidents in EIIS as of 12/17/98 into the following groupings based on a combination of the use site, registration status, and the above certainty and misuse categories:

1. Currently registered uses; certainty index is highly probable or probable
2. No longer registered use site; certainty index is highly probable or probable
3. Use site not cited; certainty index is highly probable or probable
4. Certainty index is possible, regardless of use site
5. Clear, intentional misuse (baiting, etc.), regardless of use site or certainty index

Categories #1 - 3 reflect incidents with good evidence that diazinon was the cause of the mortality. Those in Category #1 are those pinpointed to a specific use site that is currently registered and thus likely to be a continuing source of mortality. Category #2 are those involving sites no longer registered and thus not subject to reregistration. Nevertheless, the incidents likely reflect the same kind of circumstances that can lead to mortality on currently registered sites, and are important in describing diazinon risk. Category #3 incidents do not have a specific use site identified. Nevertheless, because of the certainty level of diazinon as the causative agent, they are important in describing diazinon risk. The lack of identified specific use sites may indicate that birds moved off the application site before dying, or simply that those investigating a given incident thought that the use site was understood, or that carcasses were submitted to a laboratory where the causative agent was confirmed but background information was not provided. Category #4 are those with lower certainty regarding the causative agent. Category #5 are those involving clear misuse, often where enforcement actions beyond registration changes may be needed to prevent mortality.

Data in Tables 86-88 are based on data in EIIS as of 12/17/98. As new incidents are added to the database and/or entries for existing incidents are revised, the tables will be subject to future revision.

Table 86: Number of Incidents by Registration Status of Use Site, Category of Certainty, and Use/Misuse.

Category	Number of Incidents (approx.)
I (Currently registered uses; Certainty index is highly probable or probable)	72
II (No longer a registered use site; Certainty index is highly probable or probable)	17
III (Use site not cited; Certainty index is highly probable or probable)	111
IV (Certainty index is possible, regardless of use site)	21
V (Clear, intentional misuse, regardless of use site or certainty index)	18

As seen above, the vast majority of diazinon incidents are in Categories #1-3 (Highly probable or Probable). Further investigation could probably identify use sites and reduce the number of Category III incidents. Likewise, improved initial investigation and reporting of incidents could result in fewer incidents placed in this category from the start. Nine of the 32 diazinon hearing incidents to be added were on golf courses (Category II), while the remaining 23 would be considered Category I, and will add to the tabulated values above.

An attempt has also been made to look for trends in the EIIS data. This includes examining numbers of incidents by state, species, use site, certainty index, etc. Some of these trends are examined in the following text and table (s).

New York has the largest number of incidents (61), followed by California (52), Virginia (31), and Georgia (19). These numbers are likely to be more a reflection of the superior job these states do in investigating incidents and submitting incident reports than a reflection of the actual distribution of incidents. It is likely that any state with a similar level of diazinon use on similar use sites would have similar numbers of incidents with a similar effort in investigation and reporting.

The vast majority of incidents have been with birds, as is seen in the following table. This is not surprising given the very high toxicity of diazinon to birds. Diazinon is considerably less toxic to fish than birds. Of birds, waterfowl have the largest number of incidents (114), followed by non-waterfowl (songbirds, hawks, etc.) (90) and combined waterfowl/non-waterfowl incidents (13).

Table 87: Number of Incidents by Species.

Species	Numbers of Incidents				
	Total	Highly Probable	Probable	Possible	Unlikely
Waterfowl	114	71	38	5	0
Non-waterfowl (songbirds, hawks, etc.)	90	52	29	9	0
Waterfowl & non-waterfowl	13	11	2	0	0

Fish	13	0	6	7	0
Bees	2	1	0	1	0
Butterfly	1	0	1	0	0
Waterfowl, fish, & reptile	1	1	0	0	0
Waterfowl, fish, & non-waterfowl	1	0	0	1	0
Waterfowl, non-waterfowl, & mammal	1	0	1	0	0
Totals	236	136	77	23	0

Numbers of birds killed in the above incidents range from single individuals to hundreds in the larger kills. The largest kills are generally with waterfowl. This is not surprising, since waterfowl frequently travel in large flocks and are attracted to turf areas, particularly if water is nearby. The following table provides further detail on the numbers of incidents involving various numbers of individuals per incident, separated by waterfowl and non-waterfowl.

Table 88: Numbers of Individuals and Incidents Categorized by Waterfowl and Non-Waterfowl.

Waterfowl	Number of individuals per incident	Number of incidents
	1 - 5	40
	6 -10	23
	11 - 20	26
	21 - 50	22
	51 - 100	4
	101 - 1000	9
	Unknown/NR/etc.	7
Non-waterfowl	1 - 5	60
	6 - 10	13
	11 - 20	7
	21 - 50	13
	51 - 100	4
	101 - 1000	2

	Unknown/NR/etc.	6

In conclusion, diazinon has caused widespread and repeated mortality of birds. The mortality has been well documented over many years and we have high certainty regarding diazinon's risk to birds. Diazinon was canceled for use on golf courses and sod farms due to its high risk to birds. The risk to birds is very high on other sites as well, since birds can be attracted to a wide range of turf and agricultural sites. The continued mortalities over the years make it clear that neither the modestly lowered application rates on turf sites (i.e., from a typical 6 lb ai/A in the mid-1980's to a 4-5 lb ai/A rate in the past 10 years), nor the various added label environmental hazard statements, have been adequate to prevent bird mortalities. Mortality is likely to continue in the future if diazinon continues to be used on sites where birds can be exposed.

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